# MECHANICAL DRAWING

FOR

# TRADE SCHOOLS

BY

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THIRD EDITION

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# PREFACE.

## THIRD EDITION.

THIS work on Mechanical Drawing has been prepared with the purpose in view of thoroughly grounding young draftsmen, and others of the various machinery trades, in the principles of Mechanical Drawing. It is also intended to familiarize them with modern drafting-room practice.

In the preface of the first edition we emphasized the need of teaching Mechanical Drawing by a method which should develop the student's creative faculties. We desire strongly to reaffirm this position, as these years of added experience have strengthened our belief in the vital importance of stimulating the student's imagination.

To give force to the theory we have advanced in regard to the value of developing the imagination, we beg leave to quote the following from a great modern psychologist: "There is an identity of nature between the constructive imagination of the mechanic and that of the artist; the difference is only in the end, the means and the conditions. . . . Taken as a whole, its psychological mechanism is the same as that of any other creative work."

We have added some new subject matter and have presented certain fundamentals in much clearer form than in the previous edition.

In presenting the subject of Isometric Projection, the illustration, Fig. 22, is original with us, as we have never before seen the relationship between Mechanical and Isometric shown in this simple fashion.

We feel grateful for the generous manner with which the previous editions were received and for the kindly spirit in which our attention was called to errors. We have tried to correct all errors, but will appreciate the courtesy of those who may call our attention to any mistakes discovered in this edition.

CHARLES C. LEEDS.

July, 1916.

# CONTENTS.

# LESSON No. 1.

PENCILS.—It is very important that the student of Mechanical Drawing should have good tools to work with, and just as important that he should learn to take good care of them that they may be always ready for use. No tool is more used in mechanical drawing than a lead pencil, yet no tool is so greatly abused, mainly because it is not very expensive.

Pencils for drawing are made of various degrees of hardness to suit the purposes for which they are to be used. There are a number of methods of designating the degree of hardness,—one of the commonest being to mark them 2H, 4H, 6H, etc.—the harder the pencil the higher the number preceding the H.

For drawing on the common Manilla papers, 4H is a very satisfactory pencil, though 6H wears better and does not require to be sharpened so often.

To do accurate drawing, it is necessary to keep the pencil well sharpened. The following methods for sharpening are highly desirable.

ROUND POINT.—The first method is known as the "Round Point." This is produced by first cutting away the wood, as shown in the illustration, Fig. 1, and then sharpening the lead on a file.

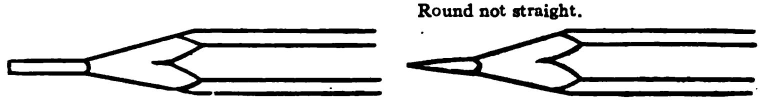



FIG. 1.

About one inch from the end of the pencil, beginning on one of the six corners, cut away the wood in a clean manner so as to bare about $\frac{3}{8}''$ of the lead; then sharpen it on the file by drawing it towards you. Turn the pencil slowly away from you, taking a fresh hold with each stroke, so as to keep the pencil turning on its axis as it is moved along the file.

FLAT POINT.—The "Flat Point" is very useful when it is desired to draw very fine accurate lines, such as the center lines, construction lines, etc. In sharpening the flat point, enter the knife about one inch from the end of the pencil on one of the flat sides (not corner), and cut away the wood in the manner shown in the illustration, Fig. 2, baring about one-half inch of the lead.

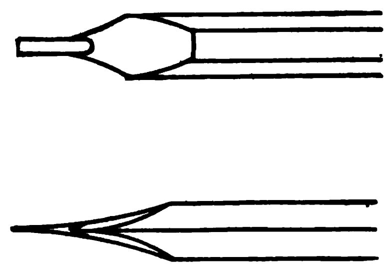


FIG. 2.

To sharpen the lead, slide it back and forth along the file, forming a long chisel-like point.

The flat side of the lead should parallel the flat side of the pencil when the point is finished.

PAPER.—The drawing paper commonly used in commercial drafting rooms is known as Manilla paper.

There are a great many different grades of this paper manufactured, but the main points necessary to keep in mind when making a selection are: color, erasing qualities, and toughness of fibre.

The standard sizes of drawings adopted by the Carnegie Technical Schools are: A sheets $22'' \times 30''$, B sheets $15'' \times 22''$, and C sheets $11'' \times 15''$.

Drawing paper should be fastened to the board as smoothly as possible, for it is very difficult to make an accurate drawing on paper which does not lie flat on the board.

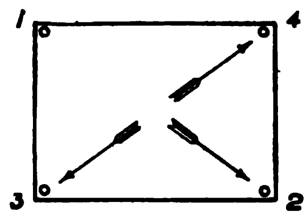



FIG. 3.

The method of mounting paper, shown in the above illustration, Fig. 3, needs very little explanation, and if the student follows the directions with reasonable care, the result will be entirely satisfactory. Place the tacks in the order numbered, stretching the paper in the direction indicated by the arrows.

Push the tacks well down, so that the heads bind the paper closely; this will also enable the T square to slip over them easily without knocking small chips out of the edge of the blade.

DRAWING BOARD. — T SQUARE. — TRIANGLES. — The Drawing Board should be made of a soft wood, well-seasoned white

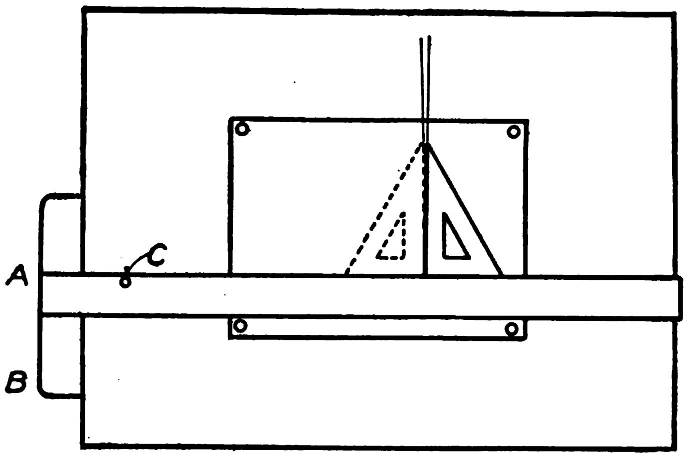



FIG. 4.

pine preferred, so that the thumb tacks may be easily pushed into or drawn from it.

One end of the board must be perfectly straight, as well as smooth, and free from bumps or high spots.

A T Square of well-seasoned pear wood is inexpensive and should give satisfactory results.

The inside edge of the head and the upper edge of the blade should be perfectly straight, and be smoothly and accurately finished.

The Triangles commonly used by draftsmen are the 45° and the 30°–60° angles; and it is preferable that they should be made of some transparent material.

The student should realize the necessity of learning to use these tools properly if he desires to do accurate work. The head of the T Square should be kept pressed against the edge of the board when in use; place the hand at A, Fig. 4, rather than at B, and press the blade flat against the board by placing the thumb at C.

The student should work from the left side of the board at all times, and when drawing *vertical lines*, he should use the left side of the triangle as a ruling edge.

The left side of the triangle is the most natural one to use, as the

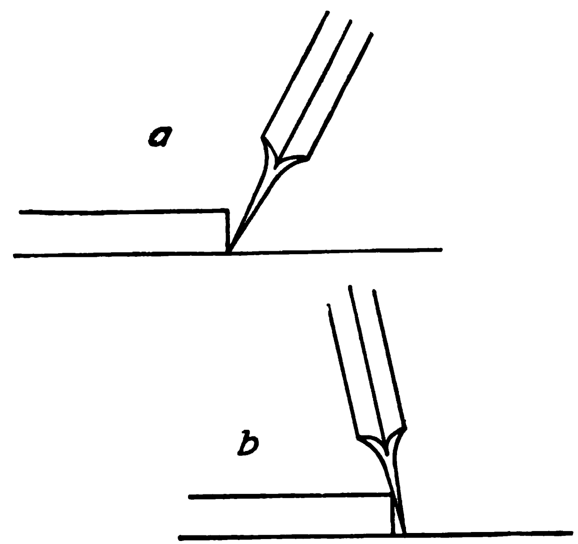



FIG. 5.

arm is held in an easy position when drawing a line away from the square blade. Besides, when tracing with ink, the student would find it extremely awkward and tiresome to use the right side of the triangle.

Hence this general statement: Accurate work is practically impossible when both sides of the triangle are used to rule vertical lines on the same drawing. The reason is that triangles are very often inaccurate.

Fig. 4 shows where the trouble lies and gives the student a way of testing the accuracy of his own triangles.

RULING LINES.—A very common cause of inaccurate work is the careless manner in which the lines of a drawing are ruled; if the student will consider the angle formed by the edge of the T Square and the surface of the paper as a groove, and then, leaning the pencil slightly *away* from the ruling edge, drag the point along this groove, he will have no difficulty in ruling a straight line.

(*a*) in the illustration, Fig. 5, shows the correct method, and (*b*) the incorrect one.

WEARING THE PENCIL POINT.—Draftsmen pick up a good many little tricks or habits that are of advantage in their work. One of them is a method of wearing the pencil point in such a way that it will stay sharp a long time.

The Flat Point is shown in illustration (*a*), Fig. 6, and the method is too evident to need further explanation.

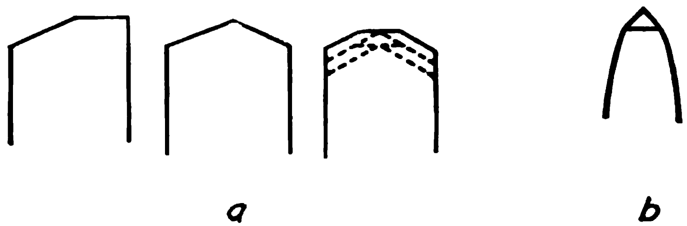



FIG. 6.

When ruling a line with the round point, turn the pencil slowly and deliberately, so that it revolves on its axis as it is dragged along the ruling edge.

This method will result in lines of an even thickness and color, and, as shown at (*b*), preserve for a long time the sharp conical point of the pencil.

SCALE.—The draftsman's flat rule (or scale, as it is generally termed), which is graduated in sixteenths on one edge and thirty-seconds on the other, will be found very satisfactory.

When selecting a scale it is advisable to choose one with the graduations cut in a white surface, as the strain on the student's eyes is much less than when using a steel scale or one of plain boxwood.

ACCURACY.—If we stop to analyze the mechanical part of the work of a draftsman, we realize that a great portion of his work consists in placing points on the surface of the paper and connecting them with lines, or in drawing lines through them.

When enough of these points and lines have been placed upon the paper, the drawing of the figure is complete.

To make a mechanical drawing accurately, it is absolutely essential that the points be placed in their proper positions.

In connecting them with lines, or in drawing lines through them, the lines should pass through the *center* of the points.

If the student is unable to do this properly, it naturally follows that he is unable to make an accurate drawing.

LINE THROUGH A POINT.—1st. With the round-point end of the pencil, make twenty small points upon the paper, one above

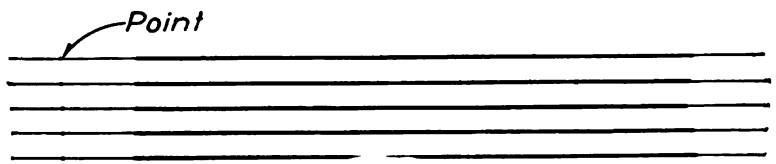



FIG. 7.

another, and about $\frac{1}{8}$ of an inch apart; then, with the flat-point end of the pencil, rule with the T square a fine, clear, straight, horizontal line through each point, as shown in Fig. 7.

These lines may be 6 or 8 inches long. Rule ten of them by adjusting the blade of the T square up to the point, and ten by placing the

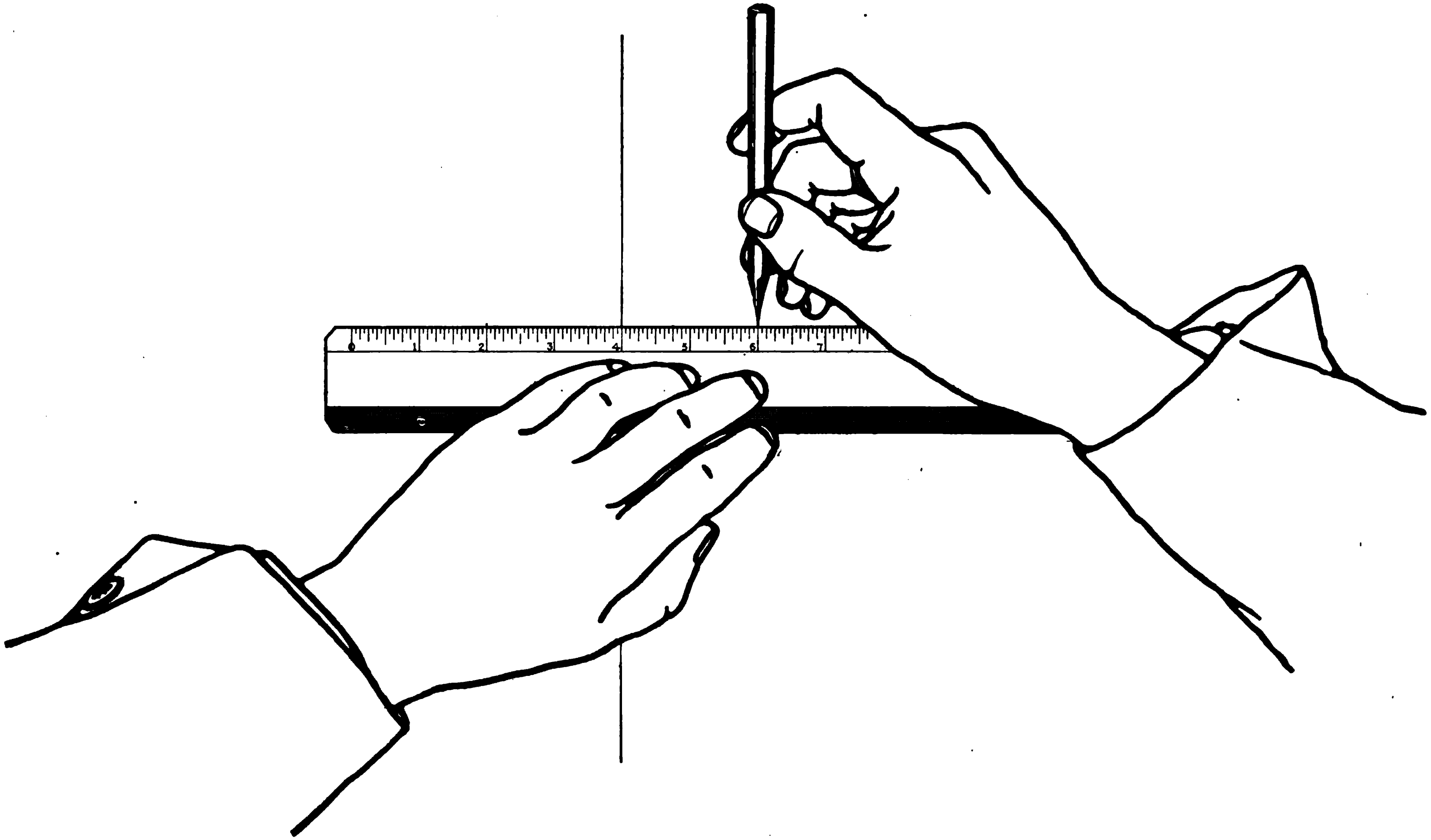



FIG. 8

pencil point in position and bringing the ruling edge gently up to it. These fine lines are called "construction lines," from the fact that when used in practice, the drawing is built upon them. The student should endeavor to "split" the point each time.

Now, with the round-point end of the pencil, "line in" about 3 inches of each line to the right of the point.

By the term "line in," we mean to make that portion of the line heavier, so that the result will be a strong, clear line, such as should be shown on a finished drawing. When lining in, the student should be very careful to cover the construction line perfectly.

Lining in a little above or a little below the construction line results in inaccurate work.

2d. Repeat above, ruling vertical lines and 45° lines, using the T square and the 45° triangle.

LAYING OFF DIMENSIONS.—3d. Draw fifteen straight lines just 4 inches long; these lines to be horizontal, vertical, and 45°.

In each case use the method described above; first a fine construction line more than 4 inches long, then, using the scale in the manner shown in the illustration, Fig. 8, lay off two points which are exactly 4 inches apart, and "line in" that part of the construction line between points.

THREE-INCH SQUARE.—4th. Using the T square and the 45° triangle, construct a 3-inch square. Rule the lines in the order shown by numbers in the illustration, Fig. 9.

Lines 1, 2, and 3 should be construction lines at first. Finish the square by lining in these sides.

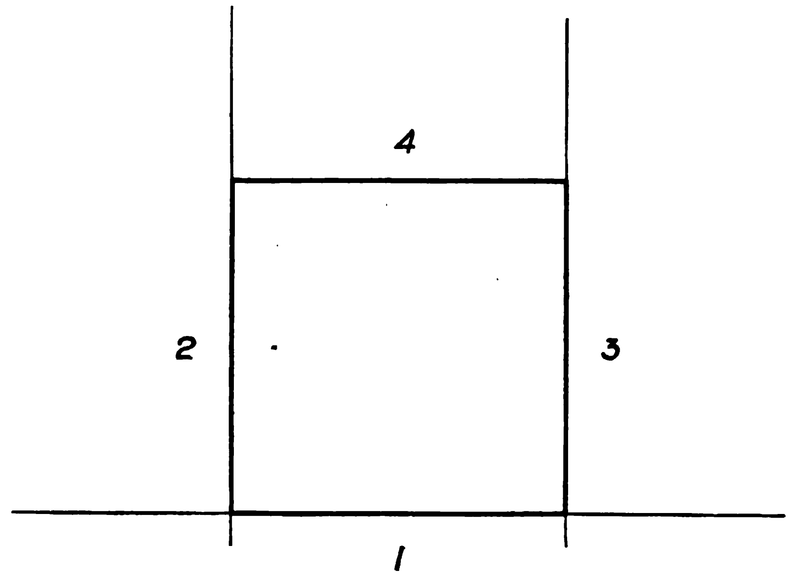


FIG. 9.

When the square is finished, the length of each side should be exactly 3 inches.

# LESSON No. 2.

ACCURACY.—The student should at all times endeavor to make accurate drawings, and he will find that it is only by constant effort on his part that this can be accomplished.

This lesson is a test in accuracy, and it is necessary that the student should exercise great care in laying out these figures.

COMPASS POINTS.—Get the pencil compasses ready for use.

In preparing the large compass, remove the pencil leg and, with the file, produce a "flat point" very similar to the "flat point" of the pencil. Trim off the sides so as to get a narrow "flat point" as shown in the illustration, Fig. 10.

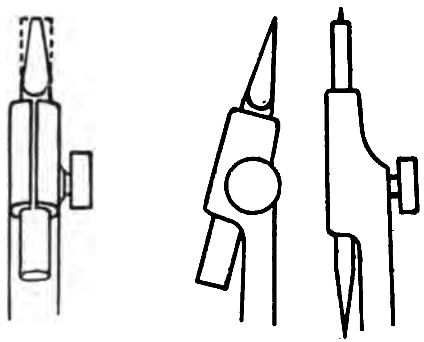


FIG. 10.

The pencil point of the spring-bow compass should be sharpened in the same manner, except that the finished point should be slightly narrower than the one in the large compass.

SETTING LEAD.—When adjusting the legs of the large compass, see that the pencil point is slightly shorter than the needle point; about to the shoulder of the latter.

The flat side of the lead should be set at right angles with the needle point. If this requirement is not met with, the compass tends

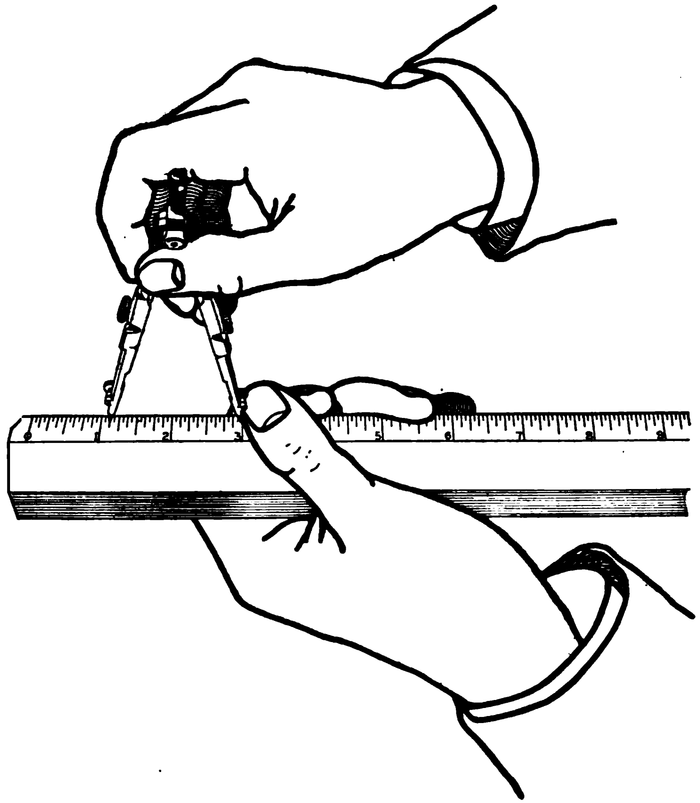


FIG. 11.

to open when it is turned in one direction, and to close when turned in the other.

After the compass legs are properly adjusted for length, test the setting of the lead by drawing a circle clockwise, then, without removing the needle point from the paper, swing one counter-clockwise. The result should be one clear sharp circle; if this is not the case, the lead should be adjusted to correct the error.

SETTING COMPASS.—With the large compass, take a radius of 1½ inches and describe a 3-inch circle.

Now, test the circle for a diameter of 3 inches, using the scale. Reset the compass and repeat above test several times, so as to gain confidence in setting the compass. When setting the latter, handle it, and also the scale, as shown in the illustration, Fig. 11.

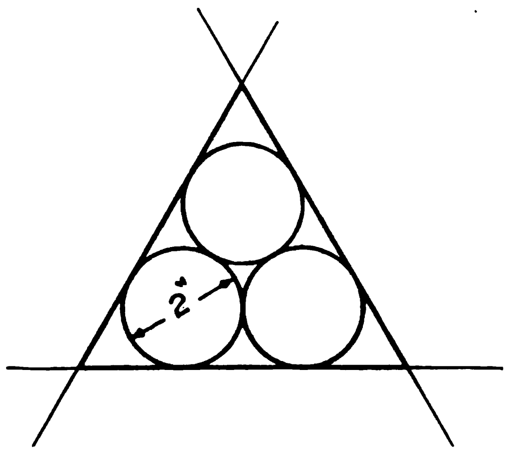



FIG. 12.

TANGENT CIRCLES.—TRIANGLE.—Describe three 2-inch circles tangent to one another.

Surround the circles by a tangent triangle. "Line in" the triangle and test it for accuracy, using the dividers; the sides should be of equal length.

Repeat this three times.

Great care should be exercised by the student in laying out this figure, which presents so many chances for error that it is quite difficult to draw correctly.

SQUARE.—Construct a 3-inch square, using the T square and triangle. The square to have rounded corners of ½-inch radius, made with the bow-pencil compass.

The finished square should be "lined in" so that there are no visible joints.

Where rounded corners join straight lines on a mechanical drawing, the joint should be so nearly perfect as to be unnoticeable. Care in these little details adds greatly to the attractiveness of a drawing, and they should never be overlooked.

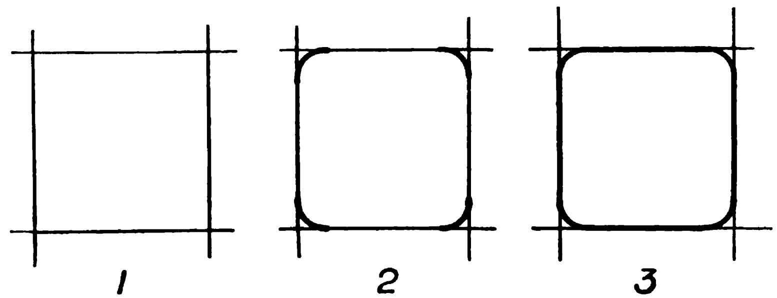



FIG. 13.

The student should observe that in the illustration, Fig. 13, the square is first laid out in faint construction lines, then the corners are rounded, and, finally, the sides are "lined in."

The rounded corner lines should be made as heavy as it is desired to make the rest of the outline, so that in "lining in" the sides, the lines may be made of the same weight.

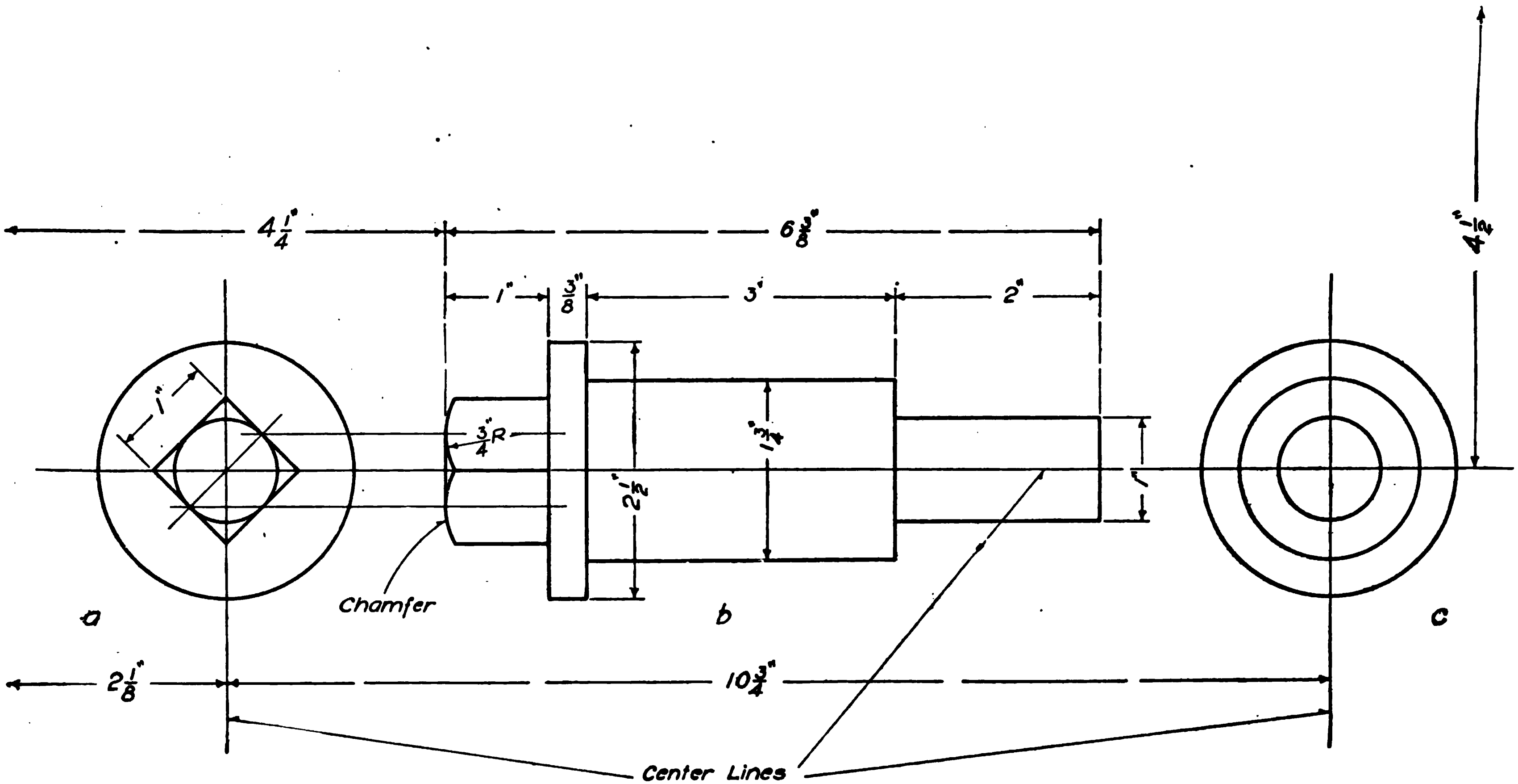
# LESSON No. 3.

FLANGED PIN.—Make a full-size three-view outline drawing of the flanged pin shown in the illustration, Drawing C–1000.

View (*a*) shows the shank end of the pin as seen from the position of (*a*). View (*b*) is a side view of the flanged pin, and (*c*) is a view of the round end as seen from the position of view (*c*). The student should study the illustration carefully, and try to understand clearly the meaning of each line. The position of each view is given in relation to the edge of the sheet.

THE DRAWING.—To make the drawing, first lay out the center lines, as they fix the positions of the views. Second, draw view (*a*), throwing in the circles, then, with the T square and 45° triangle, construct the square representing the shank end. Third, draw view (*c*), setting the compasses with care each time, so that the circles are drawn exactly to scale. Fourth, lay off the lengthwise dimensions of the pin, then draw vertical construction lines through these points (lines of any length); now place the T square so as to project the horizontal lines of the pin from the end views. With a $\frac{3}{4}$-inch radius, throw in the curved lines representing the chamfer on the shank end. Observe how the radius center line is projected from the end view.

FINISHED DRAWING.—In finishing the drawing, "line in" the whole outline with care to give it a neat appearance, and to make it clear and distinct, so that all the lines can be easily seen through the tracing cloth. Do *not* put in any of the dimensions. The finished drawing should show only the outlines of the pin with the vertical and horizontal center lines.




FLANGED PIN

CLASS Industrial

NAME John W. Roberts DATE Feb. 16_06.

SCALE Full Size DWG. No. C_1000

# LESSON No. 4.

MACHINE BOLT.—Make a full-size three-view mechanical drawing of the 1½-inch machine bolt shown in the illustration, Drawing C–1001. View (*a*) represents the end of the bolt head as seen from the position of (*a*). View (*b*) is a side view of the bolt and hexagon nut. View (*c*) is an end view of the threaded end of the bolt and of the hexagon nut as seen from the position of (*c*). The positions of the views are given in relation to the edges of the paper.

THE DRAWING.—Lay off the center lines first, so that the positions of the views are fixed at the beginning; do not let them "happen" as regards location.

In drawing view (*a*), lay out the 2¼-inch construction circle, and then with the T square and 45° triangle, draw in the outline of the head.

View (*c*) is drawn in the same manner, that is, first the 2⅜-inch construction circle, then, using the T square and the 30°–60° triangle draw the outline of the hexagon nut, and finally throw in the 1½-inch circle to represent the end of the bolt.

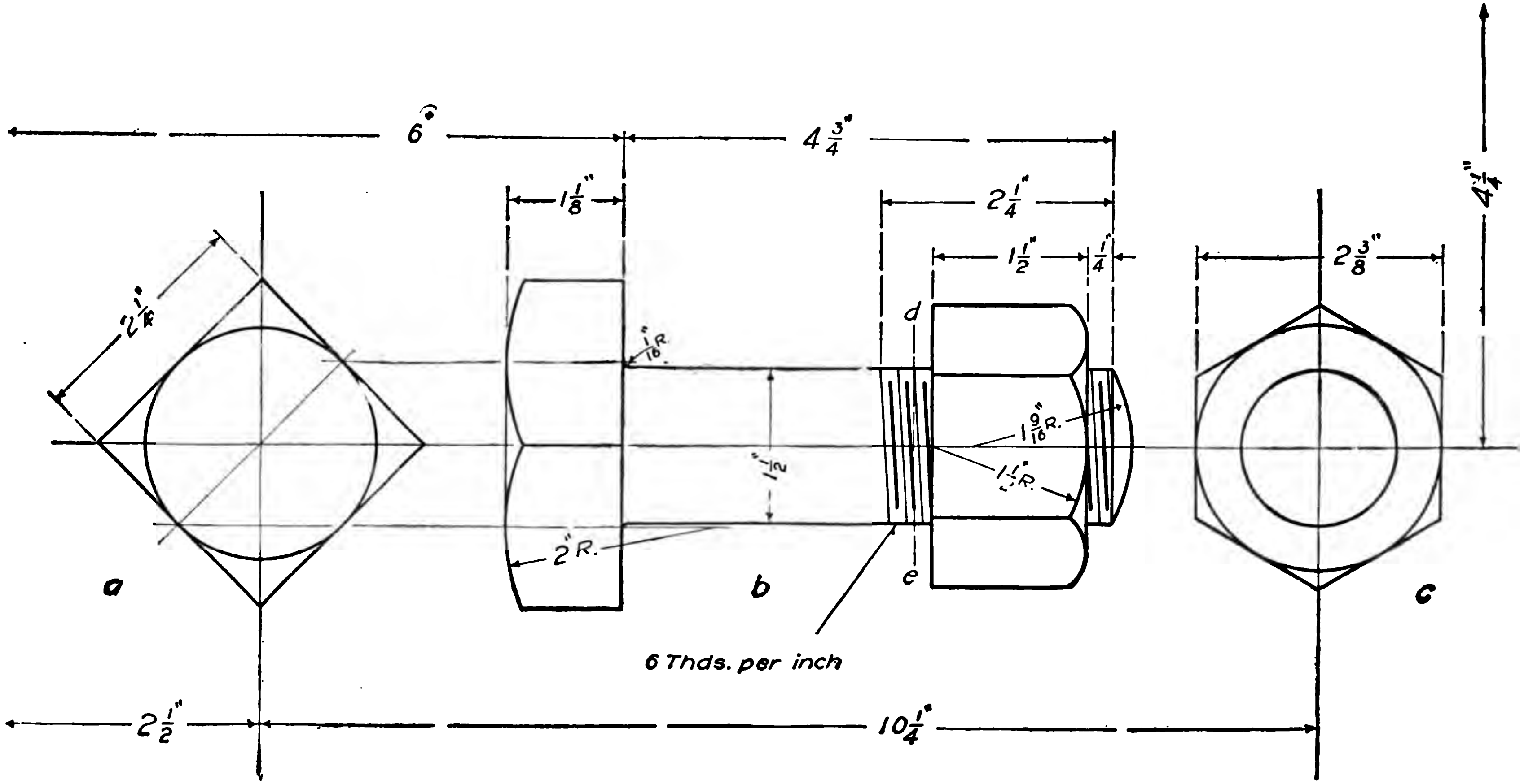
Having drawn views (*a*) and (*c*), now lay off the lengthwise dimensions of view (*b*), and draw vertical construction lines through these points (lines any length). With the T square, project the horizontal lines of the bolt from the end views, these lines to be light construction lines, until their true length is known. Now swing in the various radii, make them as heavy as the final outline is to be, and line in the bolt and nut completely, so that the whole outline stands out clearly and distinctly.

SCREW THREADS.—The threaded end of the bolt is indicated by alternate light and heavy lines, the heavy lines being shorter than the light ones. This is a conventional method of indicating screw threads, and it has the merit of being easily understood and is inexpensive.

While it is not essential that the space between the light lines should be just the same as the pitch of the thread, or that the lines should be sloped at exactly the correct angle, it is of considerable importance that the threaded surface as a whole should look approximately correct.

When the slope is correct for a single-thread screw, a line drawn at right angles to the center line of the screw should touch the end of one of the thread lines at one side and pass midway between that line and the next at the opposite side, as indicated by the light dash line *d–e*. In other words, the slope equals half of the pitch of the thread.

Place the dimensions just as shown in the illustration, and make the figures carefully, so that there can be no doubt as to their meaning. The dimensions which refer to the position of the different views should be left off, as they were intended to aid the student in locating the views, and have no other value.




CLASS *Industrial*

NAME *John W. Roberts* DATE *Feb. 20_06.*

MACHINE BOLT

SCALE *Full Size* DWG. NO. *C.1001*

# LESSON No. 5.

LETTERING.—The average student does not fully appreciate the value of being able to letter well, and while he is seldom pleased with his lettering, he usually does not like to devote the necessary time to practice. A great many young draftsmen reach the point where they are able to make a neat, workmanlike drawing, the appearance of which they will spoil when they letter and dimension it.

In making a study of the types of letters illustrated, take especial notice of the oval, which is the basis of most of the lower-case letters, and observe the proportions of this type; note also the slope of both types.

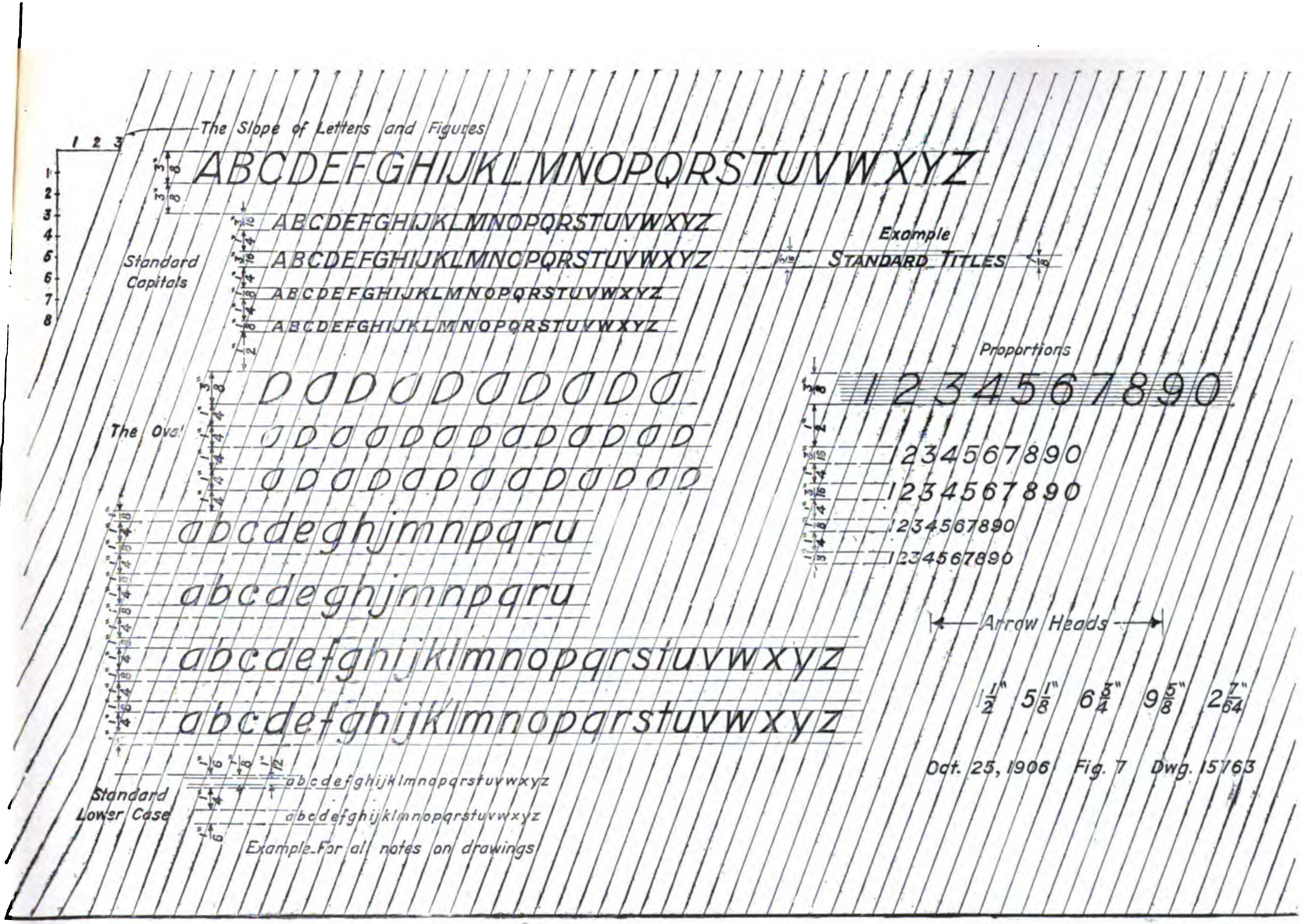
The capitals are used mainly for titles and headings, while the lower-case letters are used for all notes shown on drawings and for all other purposes, except for titles and headings.

As an aid in learning to letter, it is well to use guide lines as shown in the illustration. The student will find the slope guide lines a great help also in making letters of uniform appearance.

FIGURES.—What has been written in regard to lettering applies equally well to figures.

It is of great importance that the student should learn to make his figures so well that no one should have any trouble in reading them easily and quickly. Mistakes in the shops are very frequently caused by poorly written figures on drawings, and these mistakes are often very costly. The value of using great care at all times in placing the dimensions on drawings is thus clearly shown.

THE LESSON.—Make a neat pencil copy of the illustration, using care with both letters and figures; note carefully the proportions of both. Leave off figures showing spacing of guide lines, as these were intended merely as an aid to the student in laying out his lesson sheet.




LETTERING - FIGURES

CLASS. Industrial

NAME John W. Roberts DATE. Nov. 12, 06 SCALE Full Size DWG. No. C.1002

# LESSON No. 6.

SKETCHING.—Whatever course in mechanical drawing the student may pursue, he will sooner or later desire to know something about sketching, or, at least, he will feel the need of it.

A knowledge of sketching is exceedingly useful to men of most of the trades, and the lessons on this subject have been planned with the belief that they may assist the students to use their pencils more freely and easily in making simple mechanical drawings free-hand.

METHOD.—The method that we shall follow, we shall call the "Short-stroke Method," from the fact that as we draw a line in any direction, it is not made by a single stroke of the pencil, but by a series of short strokes. There should be the smallest possible opening between the ends of these short lines, and it would be better still if the ends were to just touch without overlapping.

The object of using these short strokes is to enable the student to correct an error in direction at any point along the line. The result is that the general direction of the line is straight, and though there may be slight errors along the line, they in nowise cause any doubt as to its meaning.

PENCILS.—For sketching, a pencil equalling an H or HB in hardness will give very satisfactory results, though a 2H Koh-i-noor will last much better. The latter, however, is just a little too hard except when used on Manilla paper.

Learn to hold the pencil easily and naturally between the first and second fingers and the thumb, in a manner very similar to that used in writing.

Do not turn the paper to suit the direction in which a line is to be drawn, but fasten it down to the drawing board and try to develop that freedom of movement of fingers, wrist, and arm which will enable one to draw a line in any direction with equal ease.

In drawing straight lines as indicated on the illustration, the student will soon discover that they are made in certain directions by a movement of the wrist mainly. In other directions it is mostly a movement of the fingers which gives the best results.

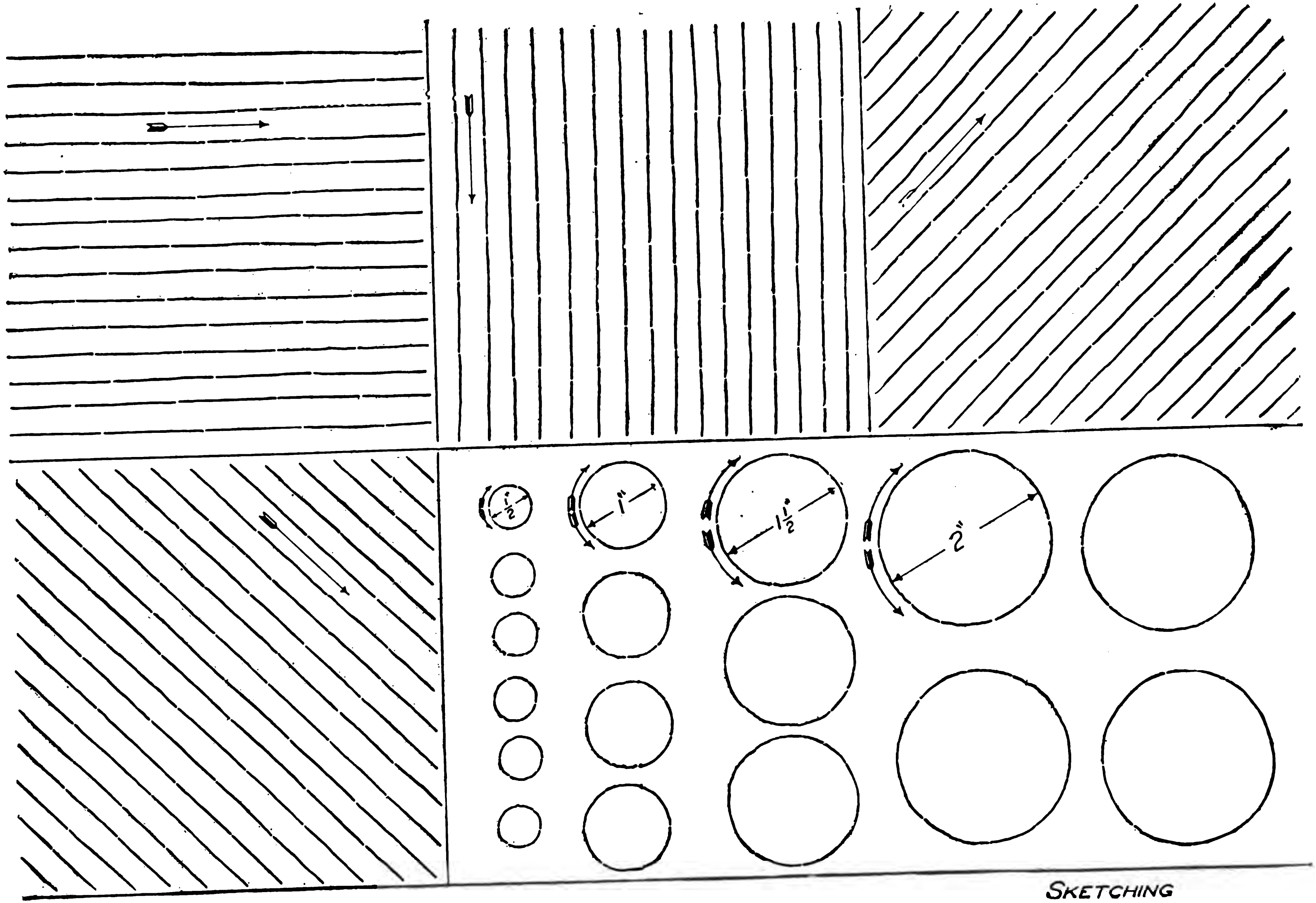
It is quite difficult to make neat circles free-hand, but by putting into practice the following suggestions, the student should obtain satisfactory results.

The student should sit upright while drawing, so that he may the better get a clear view of his work as a whole. By having the head well up over the work, the eyes can direct the movements of the pencil better, and they are in a better position to see if the desired shape is growing under the pencil, than if held close to the work. Start at a point on the left side, as indicated by the arrows, and with short strokes form the upper half of the circle. Then, starting at the same point, form the lower half in the same manner.

THE LESSON.—Fasten the drawing paper smoothly to the board and divide it into sections, as shown in the illustration.

The straight lines should be drawn about $\frac{1}{4}$ inch apart and in the directions indicated by the arrows.

Draw the circles to the sizes shown, without using a rule; try to see how nearly correct you can make them by the eye.




SKETCHING

CLASS Industrial

NAME John W. Roberts DATE Mar. 20-06.

SCALE Full Size DWG. No. C-1003

# LESSON No. 7.

PROPORTIONS.—It is a very valuable acquirement, when sketching, to be able to make the details of a drawing of the proper proportions in relation to each other.

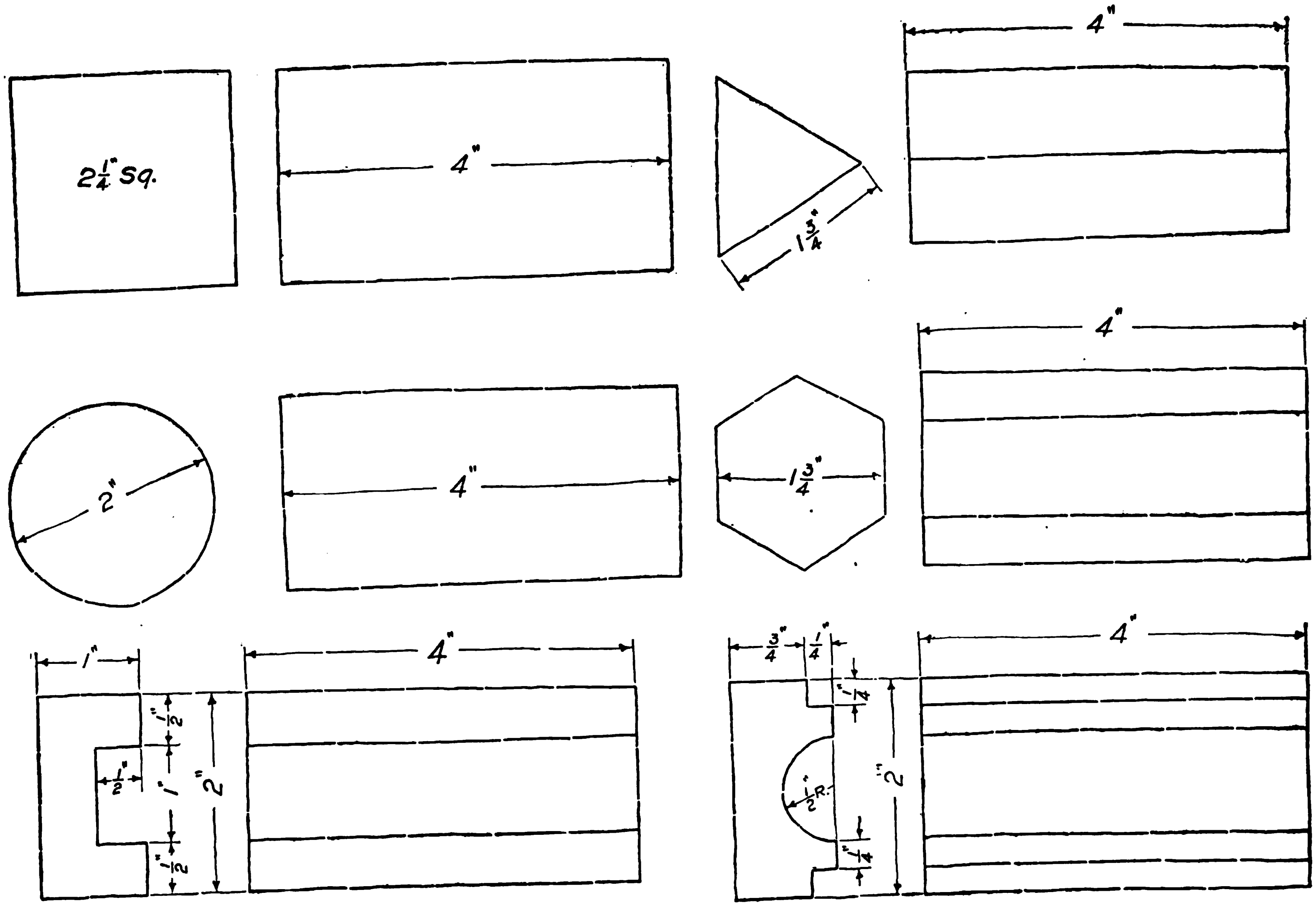
The scale of a sketch is of little importance, provided it is large enough to show clearly the piece or pieces we desire to illustrate. But that which is of importance is that each piece, or detail of the piece, should be drawn to the same scale.

To obtain this result it is quite necessary that the student should train his faculty of observation so as to have a sense of measurement, and so that, without the aid of a rule, he may be able to draw a sketch approximately to a given size.

The student will be helped to develop this faculty if, in sketching, he practises drawing to a certain scale or to given dimensions.

LESSON.—Make a neat free-hand full-size drawing of the figures shown in the illustration. Draw each figure to the dimensions given, as nearly as possible, without using a rule.

Observe that two views are shown of each piece, and try to see the relation between the views.




SKETCHING

CLASS Industrial

NAME John W. Roberts DATE Mar. 20_06.

SCALE Full Size DWG. No. C_1004

# LESSON No. 8.

METHOD OF HOLDING PEN.—In learning to trace, one of the first problems which confront the student is how to hold the instruments.

In general, the ruling pen and the pen point of the compass should be held in such a manner as to bring the points of both jaws on the paper at the same time, as shown at (*b*) of the illustration, Fig. 14.

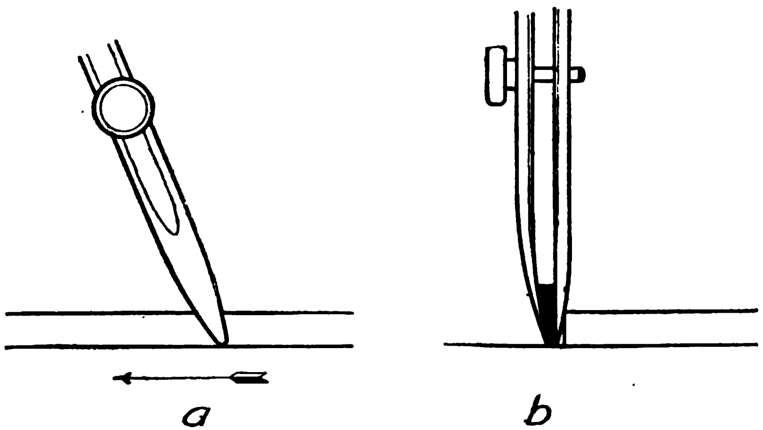



FIG. 14.

Do not lean the pen either toward the ruling edge or away from it, but hold it in a vertical plane, thus obtaining clean even lines free from a ragged edge.

While the pen should not be leaned toward or away from the ruling edge, it will be found that the ink will flow more freely if the pen is leaned slightly ***in the direction in which the line is being ruled***, as shown at (*a*).

When using the pen compass for large circles, the legs may be bent at the joints, so as to meet these conditions.

TRACING CLOTH.—The student will find one side of the tracing cloth with a glazed or calendered surface, while the other side has a dull finish. If the glossy side is used, it will be necessary to dust the surface with powdered chalk or talcum powder, as the ink will not flow freely otherwise. In a great many drafting rooms the dull side of the cloth is used from preference, as it takes ink very well without powder of any kind, though the powder makes the ink flow more freely.

CARE OF PENS.—A common mistake of most beginners is to fill the pen with too much ink, with the result that, before they realize it, there is a big blot on their work. This is not necessarily caused by the pen being filled too full, but it is frequently the cause. It is better to fill the pen oftener and to use less ink at one time.

Another very good habit to acquire is to wipe out the pen each time fresh ink is to be put in, as the ink flows more freely from a clean pen than from a dirty one.

TRACING MACHINE BOLT.—When beginning a tracing tack the cloth down carefully over the pencil drawing, then dust the surface with powder, using care to wipe off what is left after rubbing the tracing cloth with a clean linen rag, then begin by adjusting the compass pen to the width of line desired for an outline. In deciding on the width of line, the student should bear in mind that to get blue-prints with clear white lines, it is necessary that the lines of the tracing be fairly heavy; not the fine "pretty" lines that beginners are so prone to use.

The illustration, Fig. 15, shows the various steps in making a tracing: First, throw in all the circles and radii; then, beginning

at the top, rule in all the horizontal outlines; next, starting at the

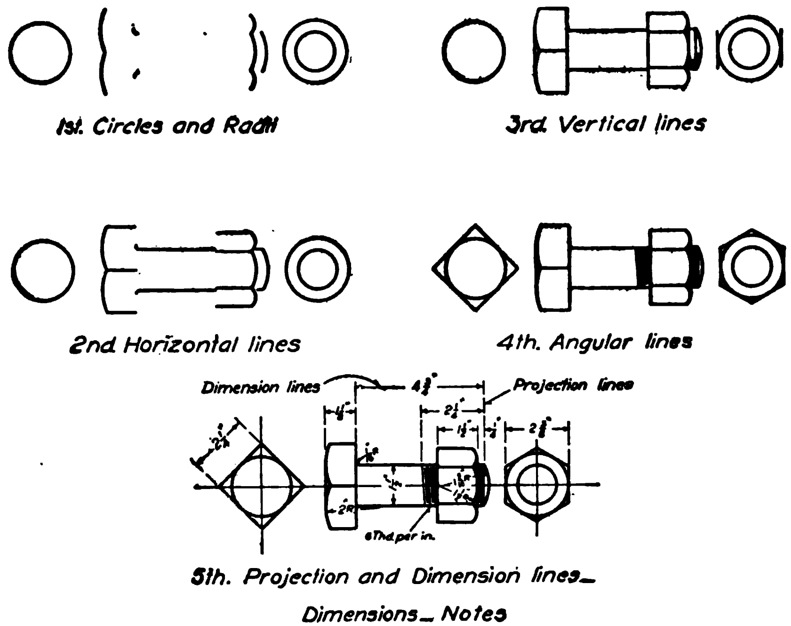



FIG. 15.

left side, rule in all the vertical outlines; and, finally, rule in the angular outlines.

Now, adjusting the pen to a much finer line, rule in the projection lines; these lines for drawings of small figures should be composed of dashes $\frac{1}{4}$ to $\frac{3}{8}$ inch long, and for large figures $\frac{1}{2}$ to $\frac{3}{4}$ inch long. Do not let the projection lines touch the figure, but leave a slight opening between the end of the line and the figure.

Next, rule in the dimension lines; these lines for drawings of small figures should be solid except for the opening left for the dimension, but on drawings of large figures they may be broken lines of long dashes—the length to suit the size of the drawing.

Now, place the arrow heads on the dimension lines and put in the dimensions, using care to make the figures clearly.

FINISHED DRAWING.—In the finished drawing there should be a marked contrast between the weight of the outlines of the figure, and of the center, projection, and dimension lines; the latter should be decidedly lighter than the outlines. When these various lines are drawn to the proper proportions and are well arranged, the figure seems to stand out by itself and is much more easily understood.

When the drawing is completed, print the title on neatly and carefully, as the looks of a good drawing will be spoiled if the printing is done in a careless, slipshod manner.

Use a Gillott's No. 303 pen point for dimensioning the drawing and for all Lower Case lettering.

A De Haan double spring No. 16 pen point will be found more satisfactory for titles and headings where Capitals are used.

# LESSON No. 9.

HIDDEN SURFACES.—Until the present time we have been using lines which could be seen on the surface, or which represented the visable surfaces of the figures that we have used as subjects for our drawing lessons.

In mechanical drawing it is constantly necessary to show by some means, surfaces or details of parts that are hidden from view behind the surface shown by solid lines.

Unless these surfaces could be indicated by some simple method, it would often be necessary to make additional drawings or, at least, additional views to show clearly the shape of the figure illustrated.

The method commonly used to indicate these hidden surfaces is to draw them in, in the proper position, but to use lines formed of short dashes. These dash lines, or "hidden lines," as they are generally called, have a distinctly different appearance from the solid outlines of the rest of the drawing, and their meaning should be readily understood.

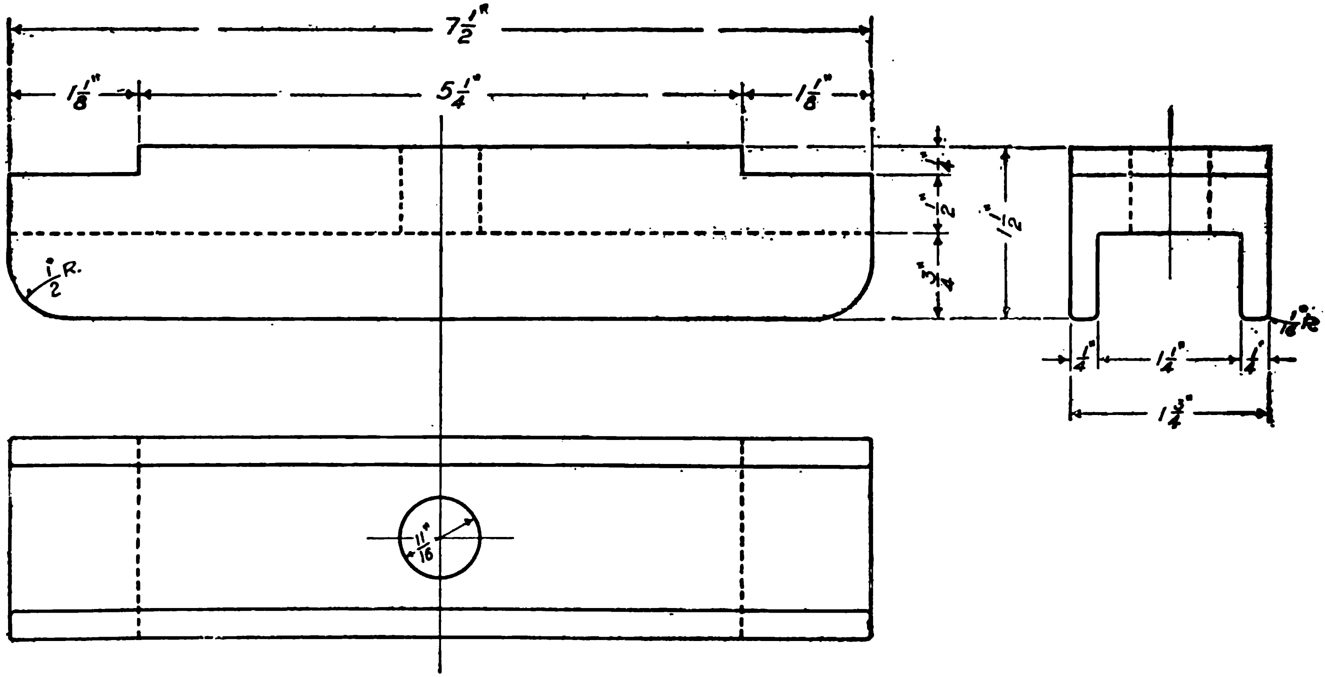
THE LESSON.—These hidden lines are the essential feature in the present lesson. As they are constantly used in mechanical drawing, we wish to call the student's attention to them.

Make a neat free-hand sketch of the clamp shown on Drawing C–1005.

Finish your sketch neatly; copy carefully all dimensions, and be sure to place your name, the drawing number, and the title of the piece upon it.

From your sketch make a full-size pencil drawing of the clamp; finish it completely with all dimensions, the title, etc.

Use the "Short-stroke Method" in making your sketch.




CLAMP

CLASS Industrial

NAME John W. Roberts DATE Oct. 6. 06.

SCALE Full Size DWG. No. C.1005

# LESSON No. 10.

SECTIONING.—When making drawings it is often necessary to show at least one view of the piece or pieces illustrated, with part cut away, or "in section," as it is generally termed.

The advantage of this method is that it helps to show the shape of the piece more clearly, and often the dimensions can be placed to better advantage on a sectional view.

As an aid in indicating that a piece is in section, the surface is covered with lines called "section lines." These lines are drawn with the aid of a 45° triangle as a ruling edge, the triangle being held against the T-square blade and moved for each line.

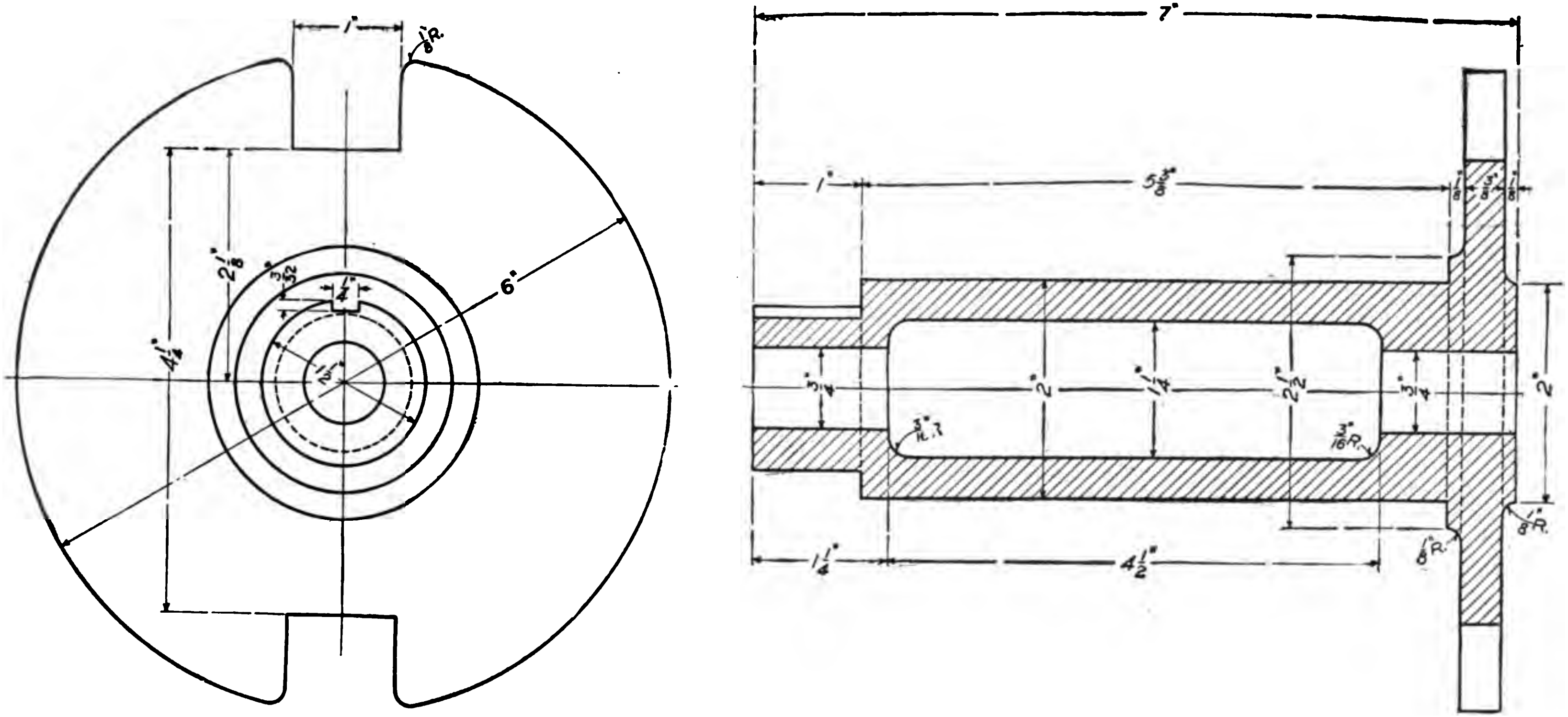
In this course of lessons we will use the section lines shown on Drawing C–1006 for *all metals*, the only variation being that the lines should be spaced close together for small pieces and farther apart for large ones.

Where two or more pieces assembled together are shown in section, the different parts are shown more clearly by sloping the section lines in opposite directions where the parts join.

THE LESSON.—The important point in this lesson is the method of showing a piece in section.

Make a neat free-hand sketch of the sleeve shown on Drawing C–1006; copy carefully all dimensions, and all necessary data.

From your sketch make a full-size pencil drawing of the sleeve. Try hard for accuracy.




CLASS *Industrial*

NAME *John W. Roberts* DATE *Oct. 24-06.*

SLEEVE

SCALE *Full Size* DWG. NO. *C.1006*

# LESSON No. 11.

**ORTHOGRAPHIC PROJECTION.**—The natural impulse of most boys when attempting to make a freehand drawing of an object, is to try to represent the object as it appears to their eye. In other words, they make a *one plane* drawing which shows two or

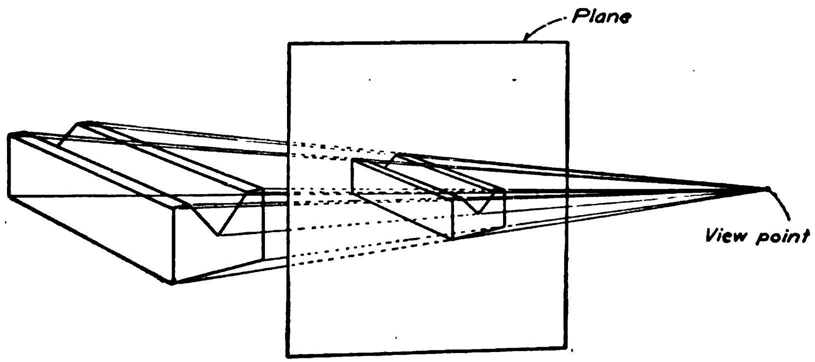



FIG. 16.

three faces or sides of an object in the one view, similar to the way the Vee Block is shown in Fig. 16.

Drawings made after the fashion of Fig. 16 are known as perspective drawings, and while this type of drawing has its place in commercial work, the method is not suitable for use by manufacturers of various forms of mechanical construction.

Fig. 16 represents the object as seen from *one* viewpoint only.

A mechanical drawing represents an object as seen from several different viewpoints, as many as are necessary to get a clear idea of the shape of the object.

Instead of one view showing several faces of an object, a mechanical drawing shows a view for each face desired, and these views are arranged in relation to each other according to certain laws of projection, in the manner shown by Fig. 17.

Mechanical drawings are suitable for the purposes of manufacturers, because they not only convey a correct idea of the *shape*

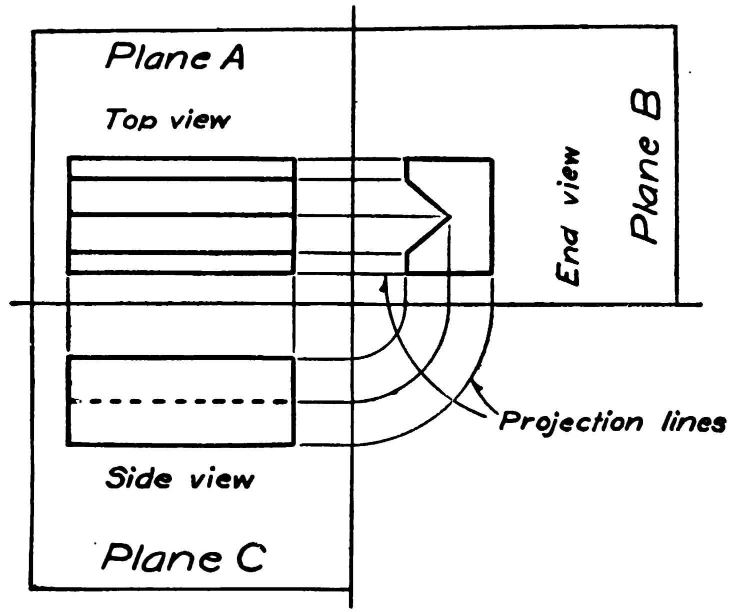



FIG. 17.

of an object, but they also carry information as to the *size* by means of dimensions, or measurements written on the various views.

To be able to read a mechanical drawing, that is, to obtain a clear idea of the shape and the size of an object, one must develop

the faculty of forming a mental picture of it from a study of the different views shown on the drawing. He must have sufficient imagination to be able to clothe the lines of the drawing with a shape.

One cannot get a clear understanding of an object from looking at a single view of a mechanical drawing, but must study all the views, looking from one to the other and trying to see the relation between them until he gradually grasps their message.

A knowledge of Orthographic Projection, or the laws by which mechanical drawings are made, is absolutely necessary if the student is to read a drawing readily and to the best advantage.

Theoretically an object is always seen through a geometrical plane in both perspective and mechanical drawing.

As a geometrical plane is a rather difficult feature for the beginner in this work to understand, we shall use a sheet of glass to represent this plane. The sheet of glass is not altogether correct as an illustration of a geometrical plane, but it will answer our purpose for lack of a better substitute.

In a perspective drawing, as shown in Fig. 16, the projection lines or rays from the viewpoint may form *any angle* with the plane. This must of necessity be so, as the object is seen from a single viewpoint.

According to the laws of Orthographic Projection, by which mechanical drawings are made, the projection lines or rays are *always* at *right angles* to the plane, that is, perpendicular to the plane.

This is one of the vital distinctions between the two methods that the student must always keep in mind if he would obtain a clear grasp of the subject.

A perspective drawing is frequently termed a "one-plane drawing," from the fact that the object is viewed through a single plane, while when making a mechanical drawing, theoretically we use a plane for each view.

To illustrate, when laying out the first view of a mechanical drawing (say the top view), the plane is *between* our eye and the object, and parallel to the face shown. Under the theory of the subject this view is projected toward us onto the plane. The end and side views are projected onto planes which parallel and lie near these faces. Then these last two planes are swung up on a level, or in the same plane, with the plane carrying the top view.

By this arrangement we are enabled to look at three sides of an object at the same time.

Suppose the student to be looking down directly on the top of a box, one side and one end of which are hinged to the top; if this side and end are swung up on a level with the top or in the same plane, then we would have an illustration of the theory of the revolution of the geometrical planes.

From the foregoing the student should note that in mechanical drawing the *relation* between the views is fixed definitely, that while the *arrangement* of the views on the drawing paper is a matter of taste, the relative positions of the views to each other cannot be changed.

To make this more clear, Fig. 18 shows three different arrangements of the views of an object, but the relative positions of the views to each other are not changed at all.

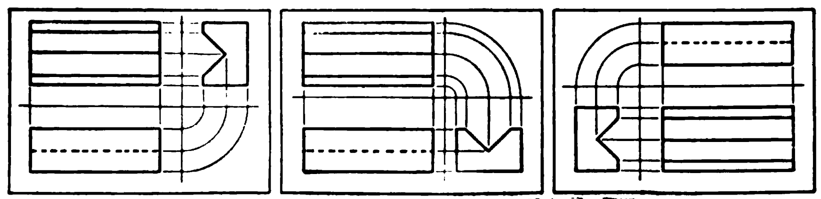


FIG. 18.

The student should make every effort to get a clear understanding of this lesson, as it is of ***fundamental importance*** in a study of mechanical drawing.

# LESSON No. 12.

SHAFT SUPPORT.—Our present lesson is an application of the principles given in our previous lesson. In this lesson the student is given an opportunity to make use of his recently acquired knowledge of projection.

The student will find his work very much simplified if he keeps in mind the positions of the planes of projection, and further if he will remember that the projection lines are always at right angles to these planes.

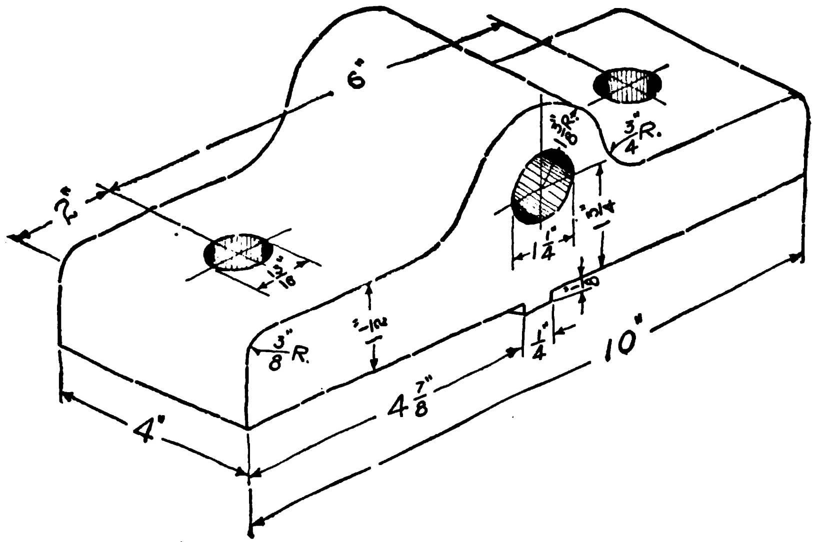
When making the mechanical drawing, the student should try to imagine just what each surface will look like by itself in the form of a view. He will also be obliged to do some thinking, to decide how he will indicate the various surfaces and edges and the type of lines to use for the purpose.

THE DRAWING.—On Drawing C–1007 is shown a perspective sketch of a shaft support from which the student is expected to make a three-view mechanical drawing.

The three views should consist of the top, the side, and one end, say the three surfaces seen in the illustration.

For the first view, choose the surface which seems to you most likely to be an aid in projecting the other views. In this case the side view showing the end of the feather key and the hole for the shaft is possibly the best view to begin with.

Arrange these views neatly on the drawing paper, finish each view carefully and see that no dimensions are left off, so that the final result shall be a drawing which leaves little room for criticism.




class *Industrial*

name John W. Roberts  date Feb. 12. 15.

SHAFT SUPPORT

scale

DWG. No. C.1007

# LESSON No. 13.

TOOL REST.—This lesson is identical in character with Lesson No. 12; the purpose is the same—to give the student an opportunity to strengthen his hold on the subject of projection.

Another point which the student should consider seriously is the faculty of mental picturing. He should try to develop his imagination by every means within reason, as this faculty is a very important factor in the makeup of the successful business man.

The *ability* to *form* a *mental image* of an object from studying the views of a mechanical drawing is *the* valuable feature of reading such drawings, as one who lacks this ability cannot use the drawing intelligently.

The usual operation is reversed in our present lesson, and in certain other lessons, as we look at the picture and from this make our mechanical drawing.

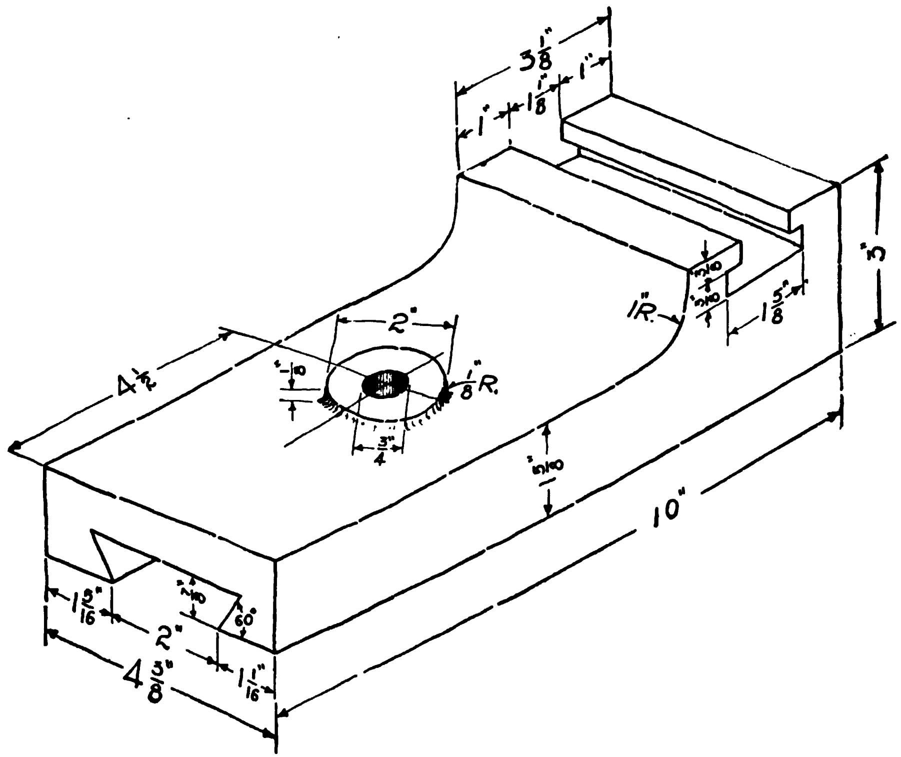
This mode of presenting the subject is adopted because of its value in helping the student to see with greater clearness the difference between the two methods of presentation, but it is also used for the reason that it is an easy step for the student from a known method to an unknown one.

THE DRAWING.—The subject of our lesson is the perspective sketch of a tool rest shown on Drawing C-1008. From this illustration the student is expected to make a three-view mechanical drawing of the tool rest.

Let these three views represent the top, one side, and one end. There is little choice as to which view to make first; either view will do, though the top view cannot be finished until the dovetail is drawn in on the end view and then projected to the top view.

It should be understood that the dovetail groove in the bottom of the tool rest runs through from end to end, and that the bolt hole on top is run through the thickness of metal.

See that no dimensions are left off of the finished drawing and that the final result is a neat, attractive piece of work.




TOOL REST

CLASS Industrial

NAME John W. Roberts DATE Feb-18-15.

SCALE

DWG. No. C.1008

# LESSON No. 14.

UNFINISHED VIEWS.—In this lesson we continue our study of the subject of projection. We test the student's knowledge of the subject by a method that differs in the mode of presentation from the two previous lessons, but the principles of projection are the same in all cases.

With one view of an object finished completely and the other two views partially, the student will find it necessary to make use of his imagination if he is to complete the unfinished views in a satisfactory manner.

The student should study each problem carefully, as it is highly desirable that he shall be able to prove the correctness of his finished work.

Certain of the lines left off of the unfinished views are hidden surface lines, others are solid lines, consequently the student will indicate his grasp of the subject by the way in which he finishes these views.

THE DRAWING.—A number of pieces of various shapes are shown in Drawing C–1009, some of the views of each piece being incomplete. The student is expected to lay out a full-size pencil copy of this drawing with all the views properly completed.

It is suggested that the student make use of projection planes as illustrated in Fig. 1, for by means of this aid the problems will be greatly simplified and there is less likelihood of the views being finished incorrectly.

Do this work neatly, showing all the necessary hidden surface lines and placing on all dimensions as shown, but keep clearly in mind the thought that the important feature is to use this work as an aid in obtaining a thorough grasp of the principles of projection.

In Fig. 1, view C is complete; finish A and B.

In Fig. 2, view B is complete; finish A and C.

In Fig. 3, view C is complete; finish A and B.

In Fig. 4, view C is complete; finish A and B.

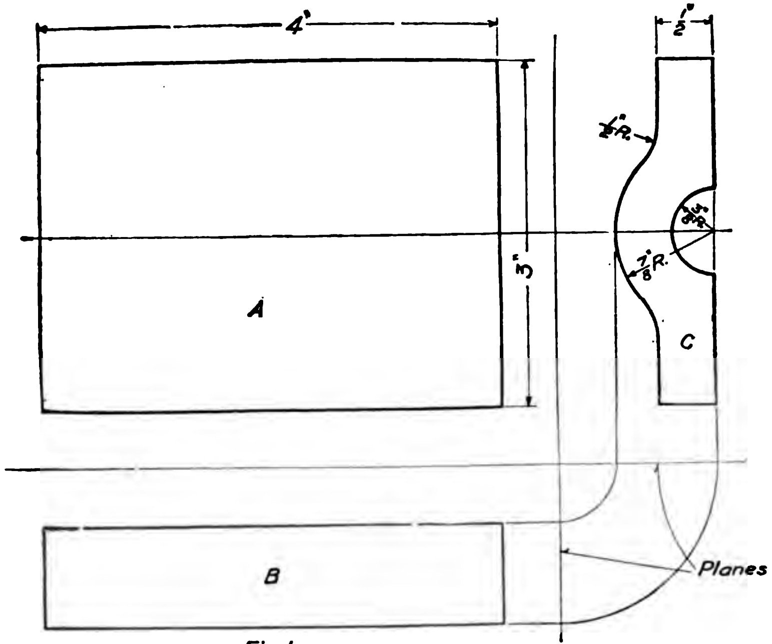



Fig. 1

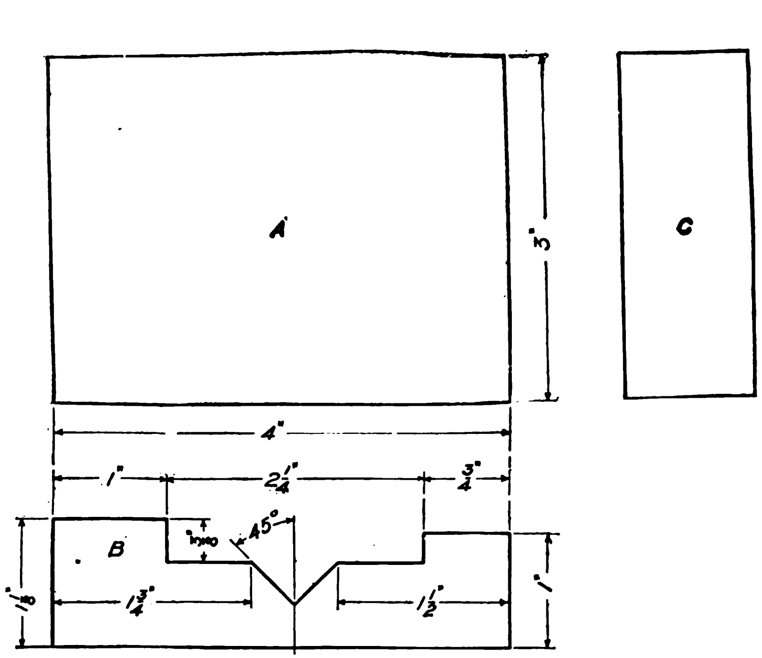



Fig. 2

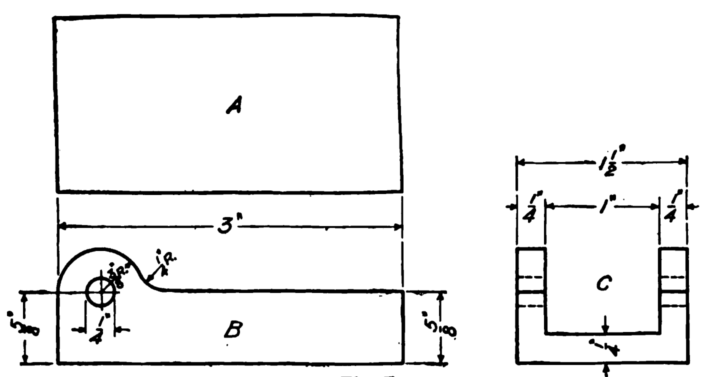



Fig. 3

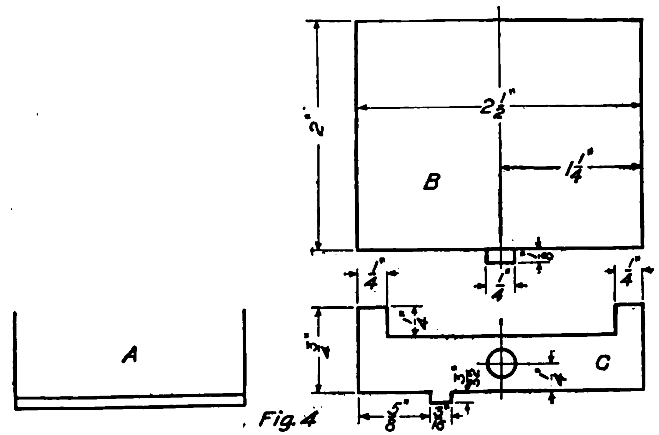



Fig. 4

PROBLEMS IN PROJECTION

CLASS *Industrial*

NAME *John W. Roberts* DATE *Sept. 22-07*

SCALE *Full Size* DWG. NO. *C-1009*

# LESSON No. 15.

REFERENCE MATTER.—The information given on Drawing C–1010 is a type of reference matter which will be of value to the student when laying out many of the future lessons.

In commercial work it is the custom to give no detail dimensions for bolts and nuts on what are known as "assembly drawings." The diameter of nuts and the diameter and length of bolts are usually given so that these items may be ordered. The dimensions necessary for drawing these details of a mechanical drawing are found in "Data Books," which are made up of a series of reference sheets.

In certain future lessons are shown nuts and bolts, the sizes of which are given, but the student will be obliged to use the information given on this reference sheet to obtain the dimensions necessary to make the drawings of these details.

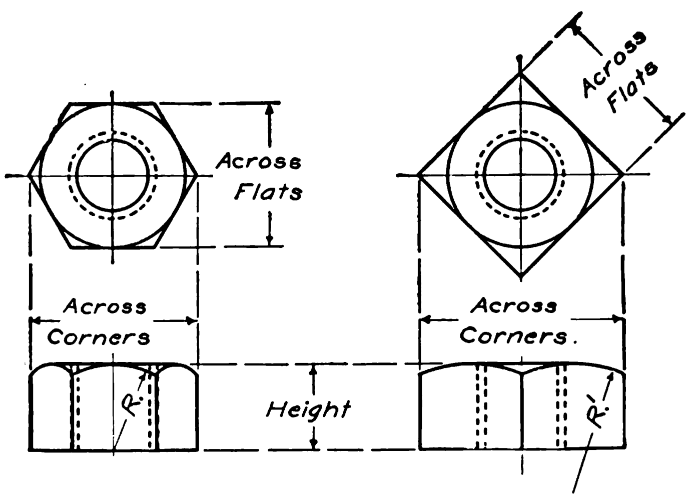
Conventional methods of indicating screw threads are also given on this reference sheet. The methods shown are among the simplest in use and for this reason are very desirable.

Frequently we have objects to make drawings of, which are of such shape that we can illustrate them to the best advantage by "breaking" out part of the object.

The main advantage gained as a rule is that this permits us to draw the object to a large scale on a smaller sheet of paper than we would otherwise be enabled to do.

It is always understood that the portion broken out is identical with that on each side of the "break."

The student is expected to lay out a pencil copy of this reference sheet, the teacher deciding the question as to sizes of nuts, bolts, etc.




## U.S. Std. for Nuts & Bolt Heads

Dia. Across Flats = $1\frac{1}{2}$ X Bolt dia. + $\frac{1}{8}''$

" " Corners (Hex.) = Dia. Across Flats X 1.156

" " " (Sq.) = " " " X 1.414

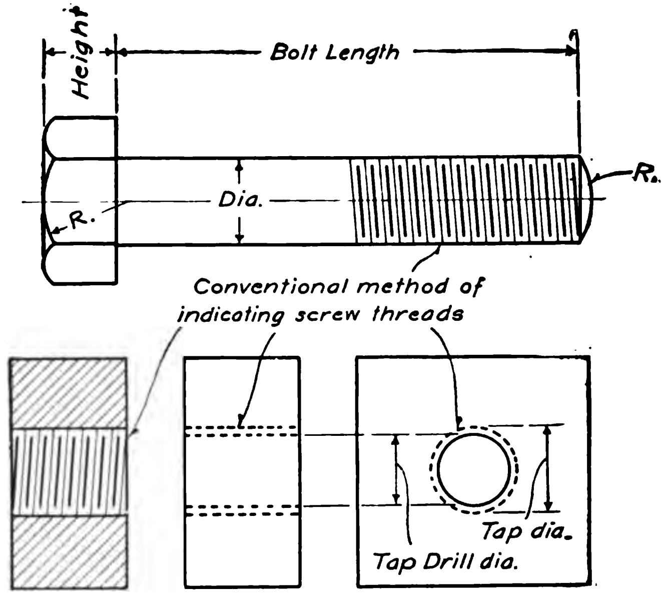
Height of Nut = Bolt dia.

" " Bolt Head = $\frac{1}{2}$ of Dia. Across Flats

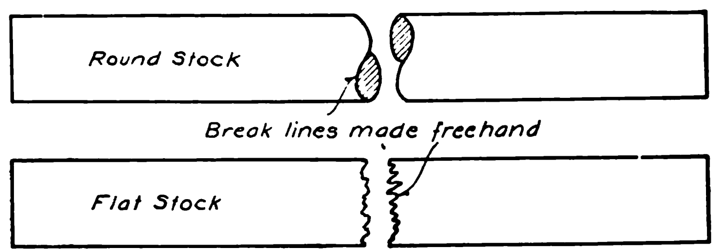
Not U.S. Std.

Radius R = Bolt dia.

" R' = $1\frac{1}{2}$ X Bolt dia.




Methods of showing a "Break" in material




CLASS Industrial

REFERENCE MATTER

NAME John W. Roberts DATE Mar. 16-15.

SCALE

DWG. NO. C.1010

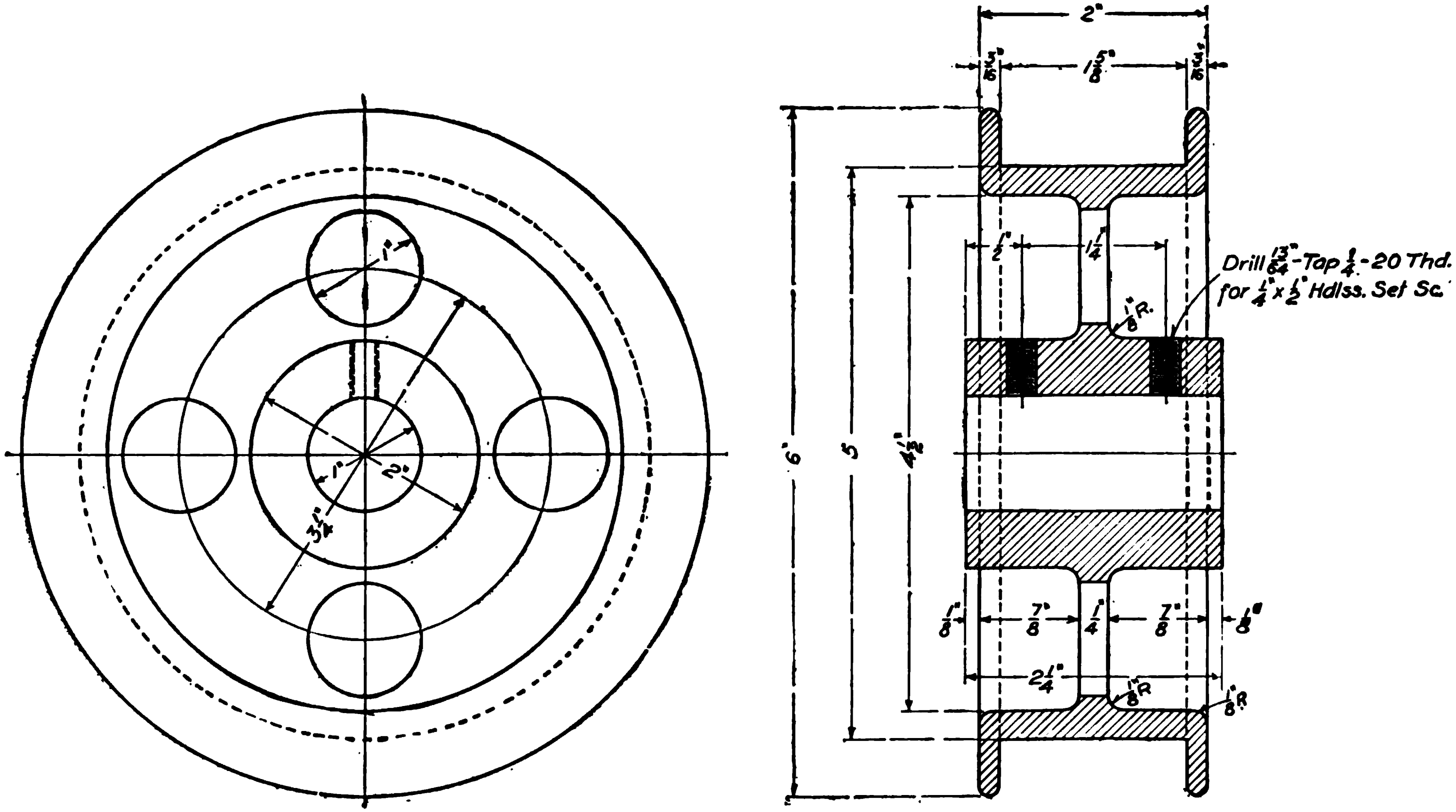
# LESSON No. 16.

FLANGED PULLEY.—The figures on Drawing C–1011 represent a side view and a true sectional view of a Flanged Pulley.

The conventional method of indicating screw threads is used in the holes for the set screws; note that the threads appear to be left hand. These threads are in reality right hand, and it is desired that the student shall reason out for himself just why it is correct to show the threads in this manner.

This lesson is intended to give the student a clearer conception of the subject of sectioning; to help him to make a mental picture of what the pulley looks like when cut in half along the vertical center line. Make a free-hand sketch of the pulley, copying carefully all dimensions and necessary information. From this sketch make a full-size pencil drawing of the pulley, placing all dimensions just as shown on the illustration.

When dimensioning a drawing, bear in mind that your drawing is to be used as an instrument to furnish exact information to some one in the shop, and unless you do your work carefully and accurately, costly mistakes may be the result.




CLASS Industrial

NAME John W. Roberts DATE Oct. 16-06.

FLANGED PULLEY

SCALE Full Size DWG. No. C-1011

# LESSON No. 17.

HAND WHEEL.—In our previous lessons on sectioning we have dealt with true sections, while, in the present lesson, the sectional view shown of the Hand Wheel is what is called a "conventional section." In other words, it is not a true section, but a special one which is used because it illustrates the shape of the piece more clearly for the pattern maker and machinist. The draftsman can lay it out more easily and quickly as well—an economy that should be considered.

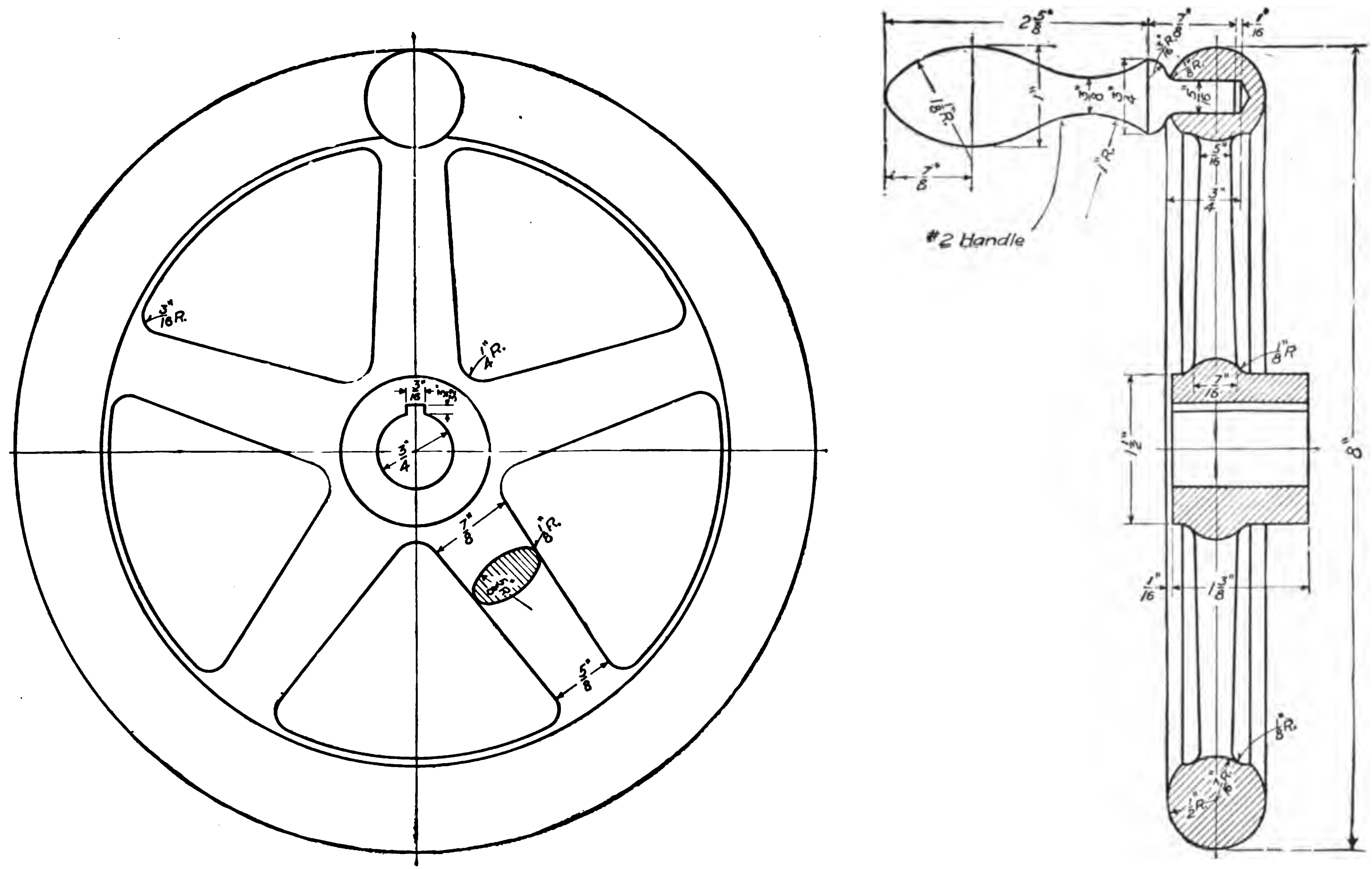
As an illustration of the convenience of special sections, note the conventional section of the arm of the hand wheel; without this section it would be pretty hard to give the pattern maker a clear idea as to the shape of the arm.

This conventional method of sectioning is used constantly on drawings of such pieces as wheels, pulleys, and gears with arms.

LESSON.—Make a full-size pencil drawing of the Hand Wheel.

Place all dimensions just as shown, with the exception of those that refer to the handle; these dimensions should be left off, as they were intended merely as an aid to the student. Mark this part "No. 2 Handle." When the pencil drawing is complete, make a tracing of it. Try to do this work neatly; make the lines of the tracing clear and distinct, keeping in mind the instructions given in Lesson No. 8.

When drawing the ball of the handle, *do not* try to make the two radii ($1\frac{1}{8}$ and 1 inch) touch, as they should be joined with a tangent *straight* line. The student should bear in mind that where radii swinging in opposite directions are to be joined, a straight line should be used for this purpose, otherwise the line appears to have a corner or uneven place. Where the radii are small, as at the stem of the handle, the rule may be overlooked.




8" HAND WHEEL

CLASS Industrial

NAME John W. Roberts. DATE Oct. 18-06.

SCALE Full Size DWG. NO. C.1012

# LESSON No. 18.

DRAWING TO SCALE.—In all of our previous lessons, the pieces illustrated have been drawn full size; in our present lesson we shall take up the subject of drawing objects smaller than full size, or "drawing to scale," as it is generally termed.

In most modern commercial drafting rooms, the drawings are made on paper of certain sizes. These standard sizes (usually three or four) are adopted to suit the needs of the manufacturer, and each of the machine parts built is shown on one of these standard-size sheets.

Small parts may be drawn full size, but large ones must, of necessity, be drawn to a smaller scale, as ½ size, ¼ size, and ⅛ size.

These are the scales usually adopted by manufacturers of machinery. The piece is drawn to the scale necessary for clearness and best suited to one of the standard-size sheets, while the dimensions are placed in the same manner as if the piece were drawn full size. In other words, the dimensions must show the sizes to which the piece is to be finished in the shop.

In drawing to a given scale, that scale becomes our unit of measurement. As an illustration, take our present lesson, in which the student is expected to make a half-size drawing of the Lathe Face Plate.

As ½ inch is our unit of measurement, ½ inch equals 1 inch, but instead of dividing each dimension by two, read it thus: "1¾ halves for 1¾ inches, 5 halves for 5 inches, ⅝ halves for ⅝ inch, etc."

If the student will carefully study the illustration in Fig. 19, he will observe that the divisions can be made on the scale by simply training the eye to perform this operation.

As an aid in readily locating a dimension on the scale, look for the nearest large graduation; the full-size dimension on Fig. 19 is 5 23/32 inches, a thirty-second less than 5¾ inches, which figure can be found at once. To find 5 23/32 inches half size, look for 5¾ inches half size and point back toward zero one-half of the space between graduations. To locate 5 23/32 inches quarter size, look for 5¾ inches quarter size and point back toward zero one-fourth of the space between graduations. 5 23/32 inches one-eighth size is located in the same manner.

By this method it is necessary for the student to keep but one dimension in mind when making a division, and when he learns to read his scale properly, he is much less liable to make mistakes than if he were to make his divisions in the usual way.

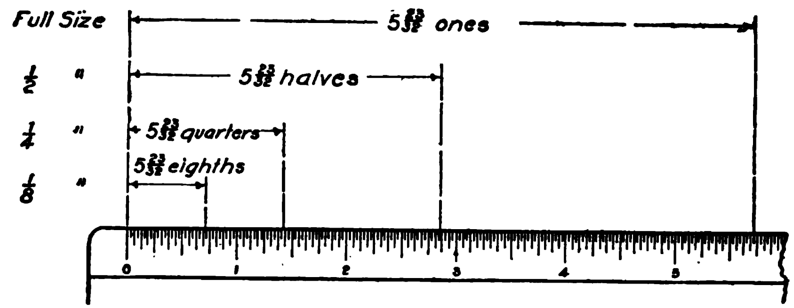



FIG. 19.

To get a radius for half-size circles, set the compasses to the dimension quarter size. For example, to draw the end view of the hub 4-inch diameter half size, take a radius of 4-inch diameter quarter size.

LESSON.—From the illustration, make a half-size pencil drawing of the Lathe Face Plate.

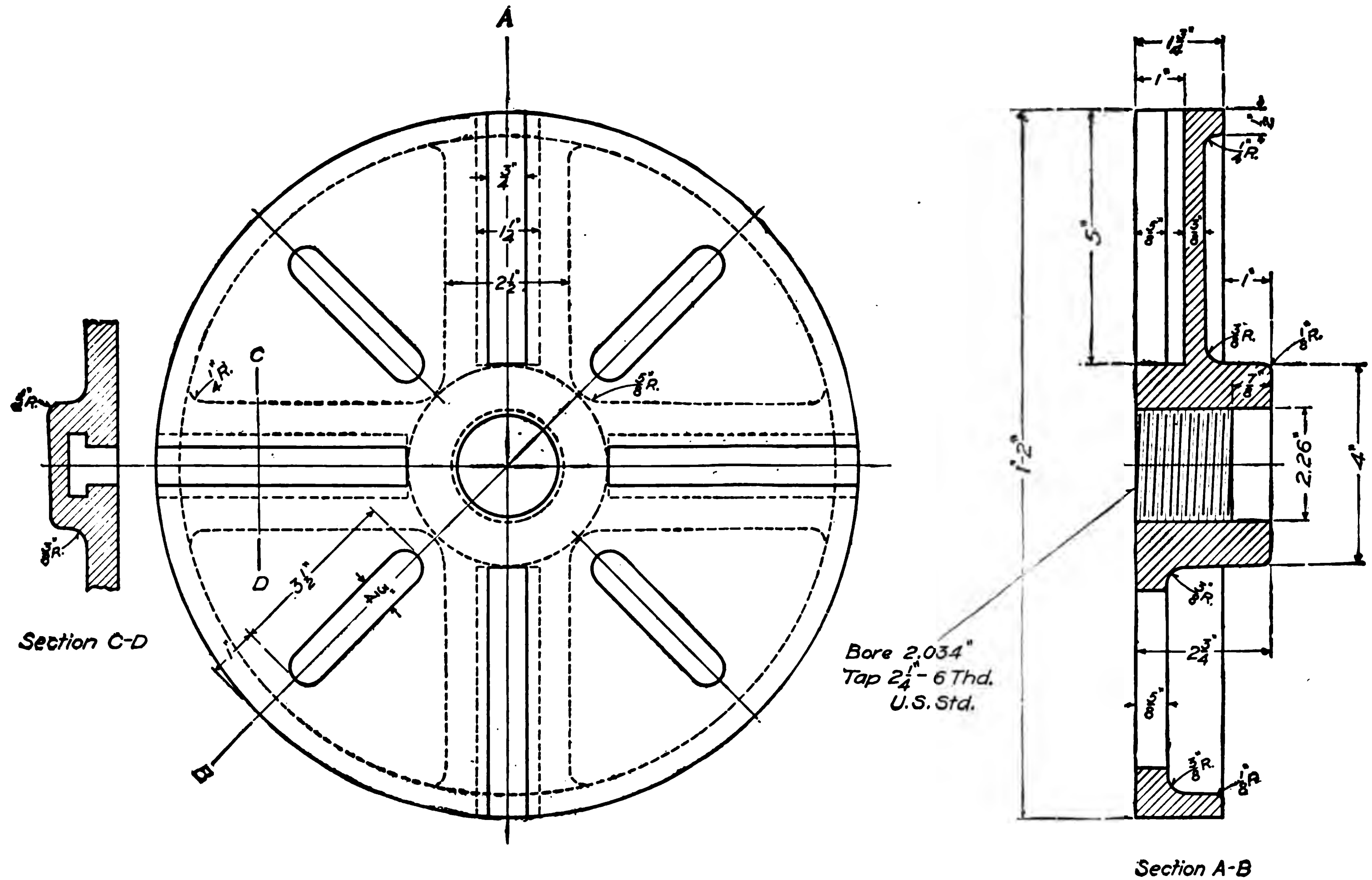
Section AB is cut along the line AB, and is a conventional method of showing a true section along this line.

Section CD is necessary to give the pattern maker a clear idea of the shape of the metal back of the T slot.

Where dimensions are given in decimals, draw that part to the nearest sixty-fourth.

Study the illustration carefully, so as to get a clear idea of the meaning of each line. Do not simply copy; try to make a *mental picture* of the shape of the piece.

Use the edge of your scale, which is graduated in sixteenths, and work from dimensions given.




LATHE FACE PLATE

CLASS *Industrial*

NAME *John W. Roberts* DATE *Oct. 20-06*

SCALE $\frac{1}{2}$ SIZE DWG. NO. C.1013

# LESSON No. 19.

COUPLING.—From the sketch shown on Drawing C–1014, make an accurate half-size pencil drawing and tracing of the Safety Flange Coupling.

One of the aims of this lesson is to call the student's attention to an "Assembly Drawing," as we term drawings whico show the parts assembled or fastened together.

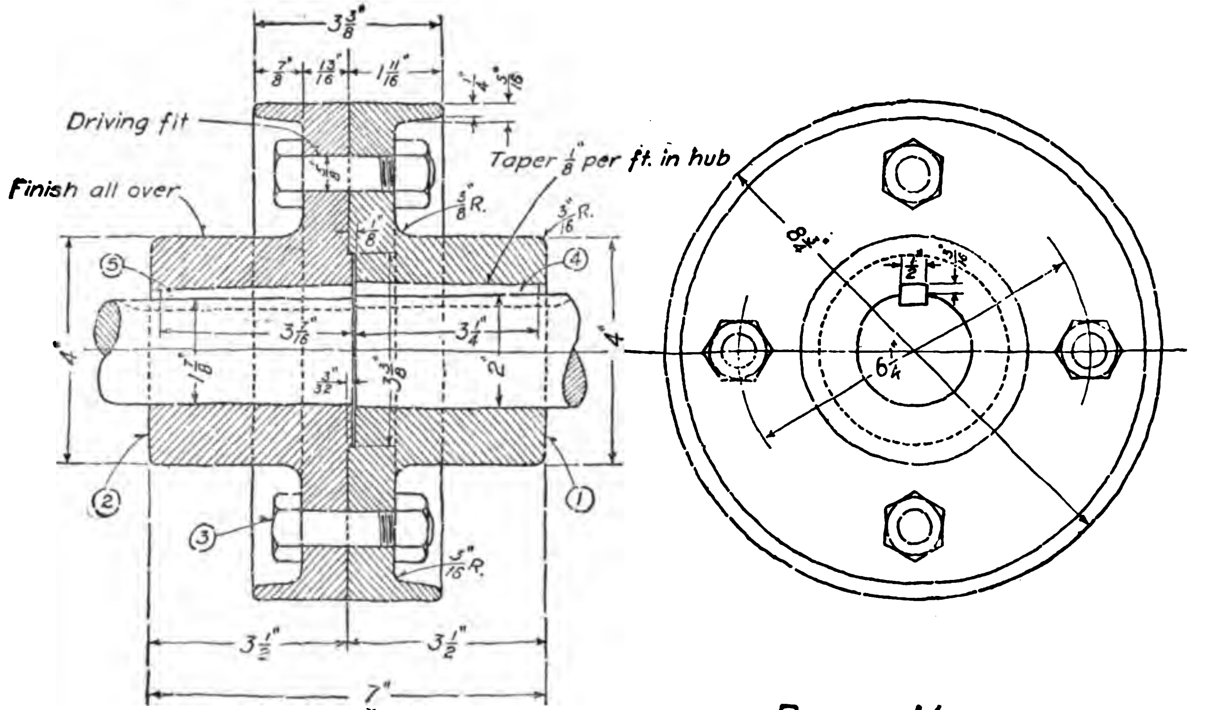
Note that the shafts are of different diameters and that each half coupling is fitted with a taper key. These keys are tapered on one side only—that which is set in the hub of the coupling. When assembling, the half coupling is forced onto the shaft and the keys are fitted before the two halves are bolted together; this brings the large end of the key at the end of the shaft, so that when the halves are fastened together the keys cannot work loose.

Observe that one-half of the coupling is made with a recess $3\frac{3}{8}$ inches diameter by $\frac{1}{8}$ inch deep, to receive the boss on the other half coupling; this is for the purpose of keeping the halves in line with each other.

The student should take especial notice of the "Bill of Material" shown on the drawing. This is a device to aid the clerical force, who usually order the materials from which the mechanism is produced.

When items are not exactly alike they must be given separate item numbers. Frequently the same pattern will do for both halves of a machine part even though they are finished differently and have different item numbers.

Remember that *neat, accurate* work is expected, not work done in careless fashion.




## BILL OF MATERIAL

| Item No. | Description and Material | Pat. No. | Req. |
|---|---|---|---|
| 1 | Half Coupling, C.I. | A.201 | 1 |
| 2 | " " " | " | 1 |
| 3 | 5/8" X 2 1/4" Machine Bolt with Nut | | 4 |
| 4 | 3/8" X 1/2" X 3 1/4" Taper Key, C.R. | | 1 |
| 5 | 3/8" X 1/2" X 3 7/16" " " " | | 1 |

9/16" 3" 7/8" 9/16"

5"

SAFETY FLANGE COUPLING

CLASS Industrial

NAME John W. Roberts DATE Nov. 16-06.

SCALE 1/2 Size

DWG. No. C-1014

# LESSON No. 20.

COUPLING.—The assembly drawing used for the present lesson is of a "Compression Shaft Coupling."

This coupling can be clamped around the ends of two shafts, the two halves of the coupling being held together by means of the bolts shown. The upper half of the coupling is fitted with a key which keeps the shafts in line.

No dimensions are shown for the bolts and nuts used on this coupling, but the student will find the diameter of bolts given on the drawing and by means of the reference sheet, Lesson No. 15, he can calculate the dimensions necessary for laying out these parts.

In laying out the frame for the "Bill of Material," the student is expected to use the same dimensions as were given in our previous lesson.

LESSON.—Make a half-size pencil drawing and tracing of the coupling shown on Drawing C–1015.

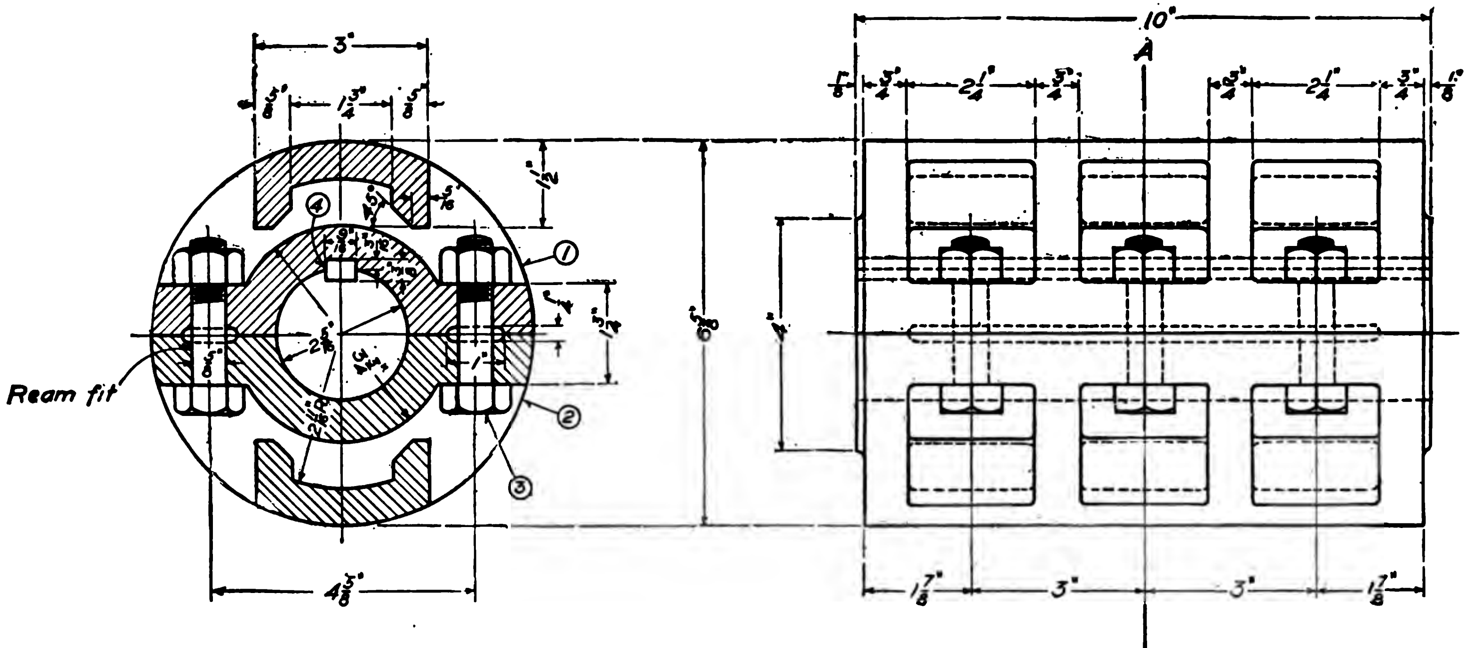
It is expected that the student will *not* copy the views as they are shown, but will lay them out as follows: Section A–B, to be shown as at present, except that the view is to be revolved on its axis (clockwise) 90° or one-fourth turn, bringing the bolts *horizontal*, with the nuts on the right-hand side.

This change in Section A–B will necessitate the lengthwise view being revolved on its axis one-fourth turn toward us, bringing the ends of the nuts on all six bolts into view.

It is understood that the dimensions given on the present illustration are to be used on the rearranged views.

As a result of these changes the lengthwise view of the coupling will present a very different appearance from the present one, consequently the student will be obliged to reason out for himself just how this view will appear, and as he places the lines of the drawing, so will he indicate his ability to represent the various surfaces properly.

While accuracy and neatness are important features of this work, mental effort is of equal or greater importance, and the student should do all in his power to stimulate the reasoning faculties.




Section A-B

## BILL OF MATERIAL

| Item No. | Description and Material | Pat. No. | Req. |
|---|---|---|---|
| 1 | Half Coupling C.I. | A-200 | 1 |
| 2 | " " " | " | 1 |
| 3 | 5/8" x 2 1/2" M.B. Tap Bolt with Nut | | 6 |
| 4 | 3/8" x 5/16" x 10" Key | | 1 |

COMPRESSION SHAFT COUPLING

CLASS Industrial

NAME John W. Roberts DATE Oct. 20-06

SCALE 1/2 Size DWG NO C-1015

# LESSON No. 21.

PROJECTION.—Two problems in projection are shown on Drawing C–1016.

(*a*), Fig. 1, is an end view of a block with all dimensions shown. (*b*) is a partly finished front view, showing the length of the block.

View (*a*) is projected upon a plane which is set at an angle of 45°; this plane is then raised to a vertical position and swung around one-fourth turn or 90°, so as to show the front view (*b*).

View (*c*) should be an end view of the block tilted at an angle of 45°.

Lay out the three views full size, finishing them completely and placing them in the positions indicated on the drawing.

Fig. 2 is a side view of a frustum of a hexagonal pyramid with the base cut away at an angle of 30°.

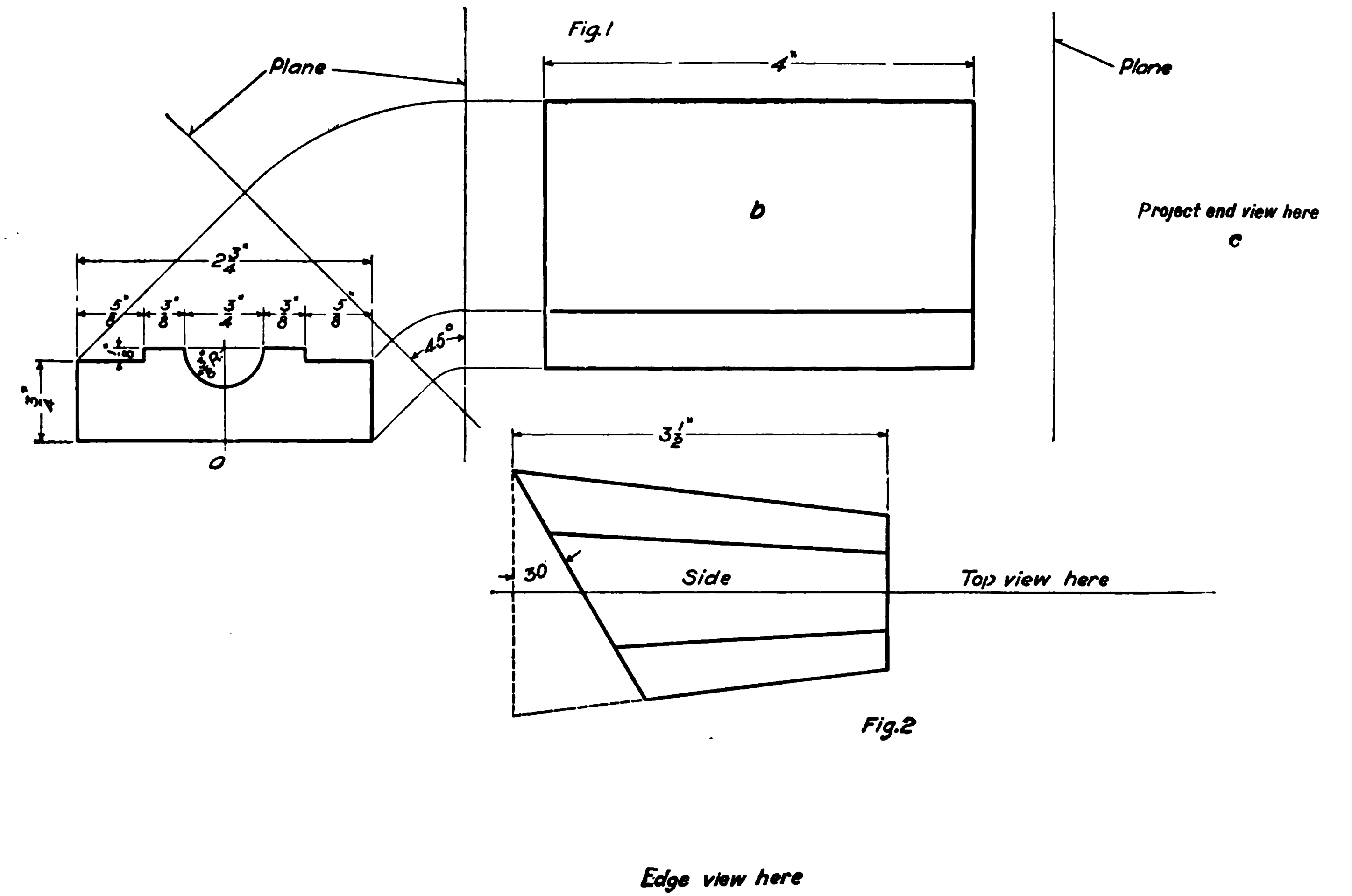
The small end or top of frustum is $1\frac{1}{4}$ inches across flats, and the large end 2 inches across flats before cutting off a portion of the base, as shown by the dotted line.

The student is expected to lay out the three views of this piece, the top and edge views to be placed in the positions indicated on the drawing.

Remember that this lesson is intended purely as a study in projection, and do this work very carefully.

If the student fully grasps the principles of projection, he will have mastered one of the most difficult and most important portions of the subject of mechanical drawing.

It is not necessary to dimension the pencil drawing.




**PROBLEMS IN PROJECTION**

CLASS *Industrial*

NAME *John W Roberts* DATE *Oct. 10-07*

SCALE *Full Size* DWG NO *C.1016*

# LESSON No. 22.

GEOMETRICAL PROBLEMS.—Before taking up the following problems in geometrical construction, the student should see that the points of his pencil and compass are in first-class order, as it is necessary that this work shall be done carefully and accurately.

The main object of this lesson is to familiarize the student with certain geometrical terms and their meaning, all of which are used frequently in mechanical drawing. This is especially necessary for those students who have not studied plane geometry.

When laying out these problems the student is expected to use the following tools *only*: pencil, both triangles, scale, and large compass.

Fig. 1. Bisect (or divide in half) a straight line.

Fig. 2. Bisect a given arc.

Fig. 3. Bisect a given angle.

Fig. 4. Divide a line $2\frac{33}{64}$ inches long into 11 *equal parts.*

Fig. 5. Divide the *space* between two lines into 13 *equal parts,* the lines to be two inches apart.

Fig. 6. Circumscribe a circle *about* a given triangle. Inscribe a circle *within* the same triangle.

Fig. 7. Through a given point draw a line tangent to a given circle, the point being on the circumference of the circle.

Problems 1, 2, and 3 are of such character that the student should be able to solve them without help.

Fig. 4. To divide a given line into an equal number of parts, draw a construction line, at any angle and of any length, from one end of the line which is to be divided, then using the scale, lay off on the construction line the number of parts desired. Now with one triangle as a ruling edge, and the other as a base, set the ruling edge in line with the last point on the construction line and the end of the line to be divided and connect these two points.

All the other points may be projected from the construction line to the original line in like manner, keeping the ruling edge parallel with the end line.

Fig. 5 is an adaptation of the construction described for Fig. 4. The scale is tilted to an angle which will bring the number of divisions desired between the lines, then the points are set off opposite the graduations representing the unit of division.

Fig. 6 is a combination of Figs. 1 and 3 and should be within the comprehension of the student.

The student should not have much trouble with Fig. 7, especially if he will observe that the point of tangency is located where the radius of the circle intersects the tangent line, when these two lines are at right angles to each other.

The ability to *make* this drawing is of itself of little value, but if the student fully grasps the principles involved in these problems and applies them to later work, this lesson will be of considerable value.

Fig. 1

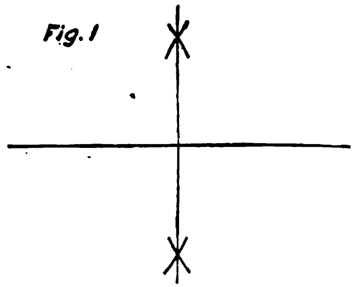


Fig. 2

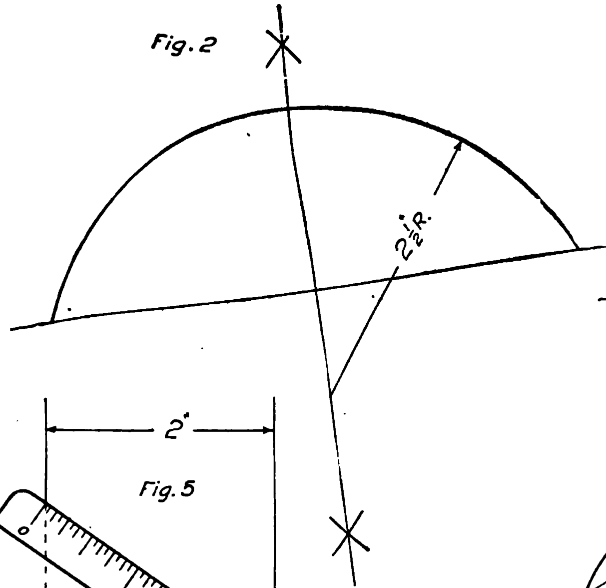



Fig. 3

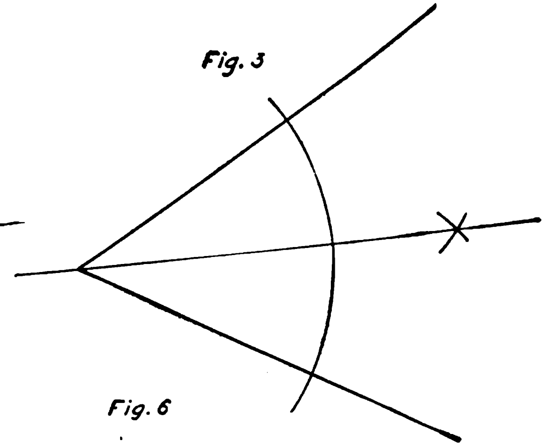


Fig. 4

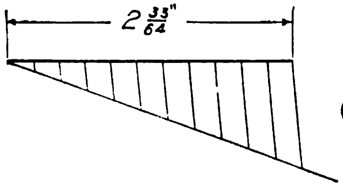



Fig. 5

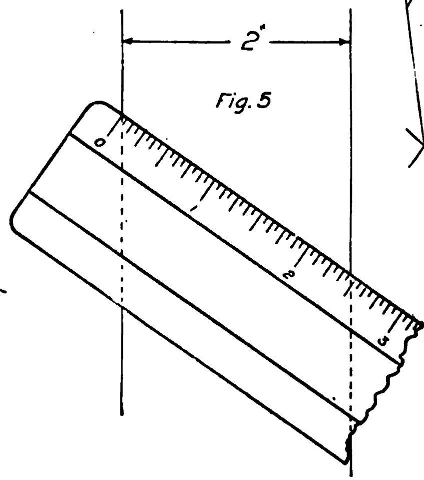



Fig. 6

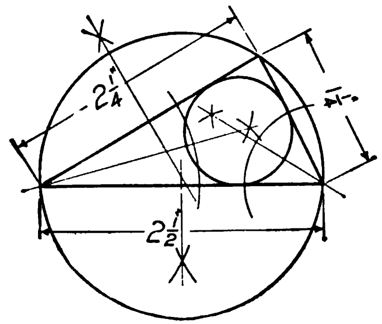
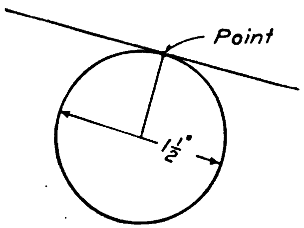



Fig. 7




GEOMETRICAL PROBLEMS

CLASS Industrial

NAME John W. Roberts DATE Nov. 20-05.

SCALE Full Size DWG. NO. C-1017

# LESSON No. 23.

THE ELLIPSE.—Make a neat pencil drawing of an ellipse by the three methods indicated, and of the elliptical curve shown on Drawing C–1018.

When drawing the ellipse, make the major or long axis $3\frac{1}{2}$ inches, and the minor or short axis 2 inches in each case.

For Fig. 1, lay off the major and minor axes to the lengths given above; take a straight edge made of any suitable material, as cardboard or wood, and, on one edge, mark off the points AB equal to half the minor axis; from A, mark off point C equal to half the major axis. Place the straight edge so that the point B comes on the major axis and point C on the minor axis; now, with the pencil, mark a point on the drawing paper at A. Shift the straight edge and repeat (keeping B and C on the major and minor axes respectively), placing a sufficient number of points on the paper to enable you to trace a curve through them easily.

The method illustrated in Fig. 2 is of such a nature that the student should be able to solve the problem without assistance.

Fig. 3 is known as the "Three-radii Method."

Construct the rectangle ADCEB. Draw the diagonal AC. Through D, draw DF at right angles to AC. Then, F is the center for arc GCH, and J is the center for arc KAL.

Make OM=OC. Describe the semicircle AM.

Make OP=CN. With center F, describe arc RPS. Make AQ=ON. Then, with J as center and radius JQ, describe arc intersecting arc RPS at T. T is the center for the tangent arc LG.

To construct the curve shown at Fig. 4, divide the base lines of the curve into the same number of equal parts (any number) and connect these division points by straight lines. The combined outer surfaces of these lines form the desired curve.

Fig. 1

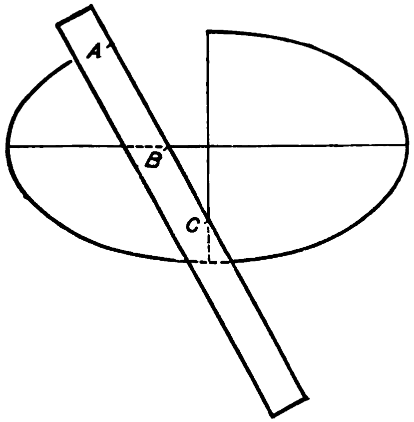



Fig. 2

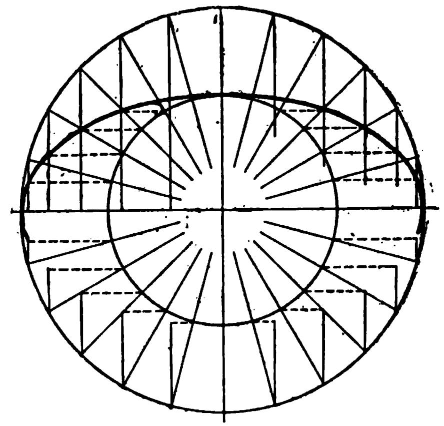


Fig. 4

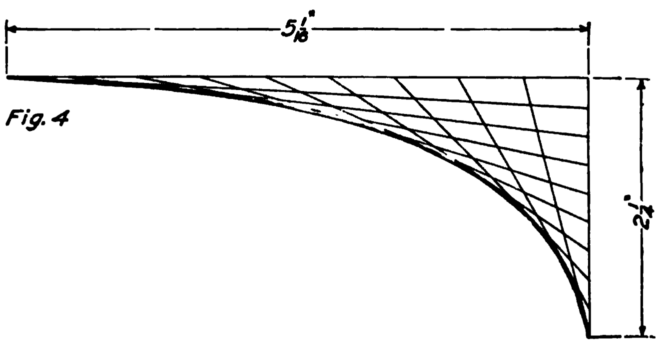
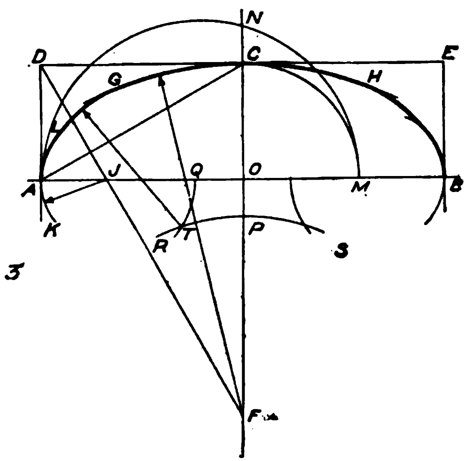



Fig. 3




THE ELLIPSE

CLASS Industrial

NAME John W. Roberts DATE Dec. 18-06. SCALE Full Size DWG. No. C-1018

# LESSON No. 24.

ENGINEERING CURVES.—The principle of this lesson is to *generate the path of a moving point.* The curves illustrated are constantly used in engineering work, and a knowledge of their construction should be both interesting and valuable to the student.

The cycloid is the curve generated by a point on the circumference of a circle when rolled along a straight line. When the generating circle is rolled *upon* another circle, an epicycloid will be generated.

When the generating circle is rolled *under* another circle, a hypocycloid will be generated.

To generate the cycloid mechanically, lay off the base and center lines; set the dividers to any short space (so that the length of the chord is about equal to the arc), in this instance ¼ inch, and step off 16 or 18 points on the base line. Erect perpendiculars through these points; swing in the generating circle from these different points, so as to place the circle in the different positions which it would assume in making one complete revolution. Now, with the dividers, step off on the second circle the distance it has rolled along the base line, in this case ¼ inch. Repeat for each new position of the generating circle (measuring with the dividers the distance around the circle that it has rolled along the base line), until a complete revolution has been made, then trace the curve through the points thus found.

The epicycloid and hypocycloid are generated in the same manner, the base circle replacing the base line of the cycloid.

The involute is the curve generated by every point in a cord as it is wrapped upon or unwound from a cylinder.

To develop the involute mechanically, unwind a little bit of the cord at a time, and step off upon the line the distance unwound.

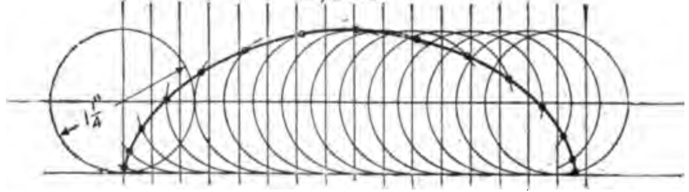
Set the dividers to ¼ inch and step off 10 or 12 divisions upon the base circle; from these points draw tangent lines to represent the cord in different positions when being unwound.

The helix or screw is the curve which would be generated upon a cylinder revolved at a constant speed against a point, the point moving along at a constant speed parallel with the axis of the cylinder.

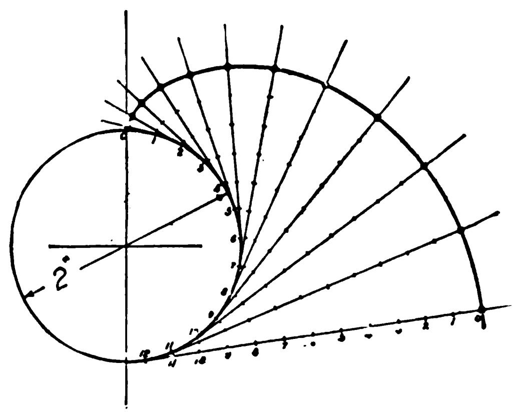
To generate this curve mechanically, divide the circumference of the cylinder into any number of equal parts, in this case 25, numbering these points from the left on the center line, as shown. Divide the pitch distance on the cylinder into the same number of equal spaces (25) by which the circumference of the cylinder was divided.

Now locate points on the side view of the cylinder at the intersection of the vertical division lines with the horizontal projection lines (these lines being projected from the points on the end view of the cylinder); then trace the curve through the points thus formed. This subject requires very accurate and careful work on the part of the student.

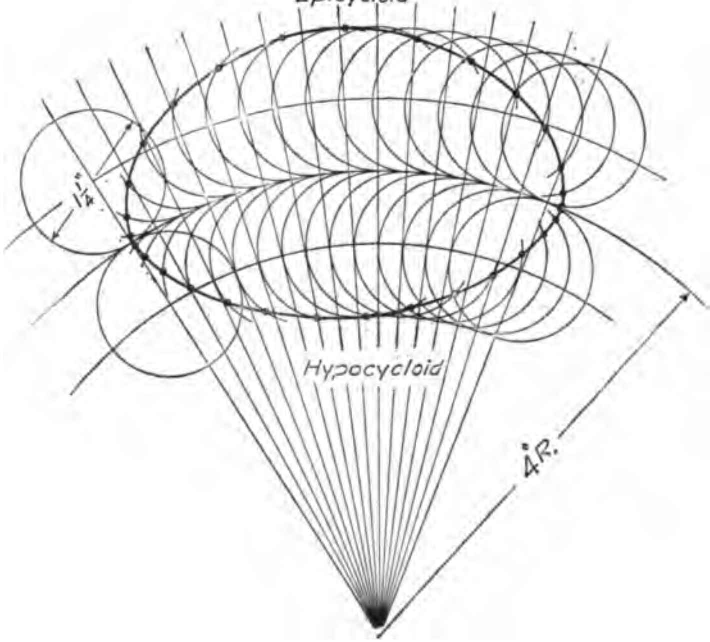
Cycloid



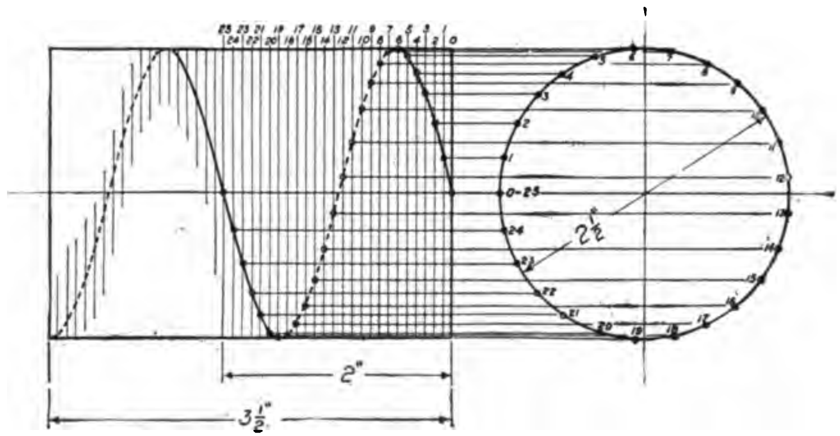

Involute




Epicycloid




Helix or Screw - 2" Pitch




CLASS Industrial

NAME John W. Roberts DATE Feb. 6-07.

ENGINEERING CURVES
THE PATH OF A MOVING POINT

SCALE Full Size DWG. NO. C-1019

# LESSON No. 25.

SPUR GEAR.—From Drawing C–1020 make a full-size pencil drawing of the 24-tooth spur gear illustrated.

The student should study carefully the following memoranda, as he is expected to make use of them in obtaining the sizes of teeth, diameters of gear, etc.

If grooves are cut in the face of a smooth wheel, the parts between the grooves are called *lands*. A part added to a land is called an *addendum*. A land and addendum together is a tooth. Between the teeth are spaces. A toothed wheel is called a *gear wheel*, or simply a *gear*. When the teeth of two gears engage together, the gears are said to be *in mesh*. Two or more gears in mesh are called a *train of gears*. The circumference of the smooth wheel in which the grooves are cut and to which the addenda are added is called the *pitch circle*. The teeth of meshing gears should be so formed that their pitch circles roll together without any slip. The word "diameter" when applied to gears is understood to mean the *pitch diameter*, that is, the diameter of the *pitch circle*. *Diametral pitch* of a gear is the number of teeth to each inch of its pitch diameter. Circular pitch is the distance from the center of one tooth to the center of the next tooth, measured along the pitch circle. A *gear blank* is the wheel before the teeth have been cut into it.

In modern practice the proportions of involute cut teeth are as follows: The tooth thickness, T, is equal to the space, S. The addendum, A, is equal to $\frac{1}{\text{Diametral Pitch}}$; thus for 4 pitch the addendum is $\frac{1}{4}$ inch. The *clearance* is generally made one-eighth of the addendum height; the depth, D, is equal to A, with clearance added.

The radius, R, at the root of the tooth is about one-sixth the distance B, but varies greatly. The rim thickness, C, is usually made approximately equal to tooth depth.

USEFUL GEAR FORMULAS.—Circular Pitch or C.P.$=\frac{3.1416}{\text{DP}}$.

Diametral Pitch or D.P.$=\frac{3.1416}{\text{CP}}$.

Pitch Diameter$=\frac{\text{Number of teeth}}{\text{DP}}$.

Distance between the centers of two gears$=\frac{1}{2}$ of $\frac{\text{N}+\text{n}}{\text{DP}}$.

N = number of teeth in large gear; n = number of teeth in small gear.

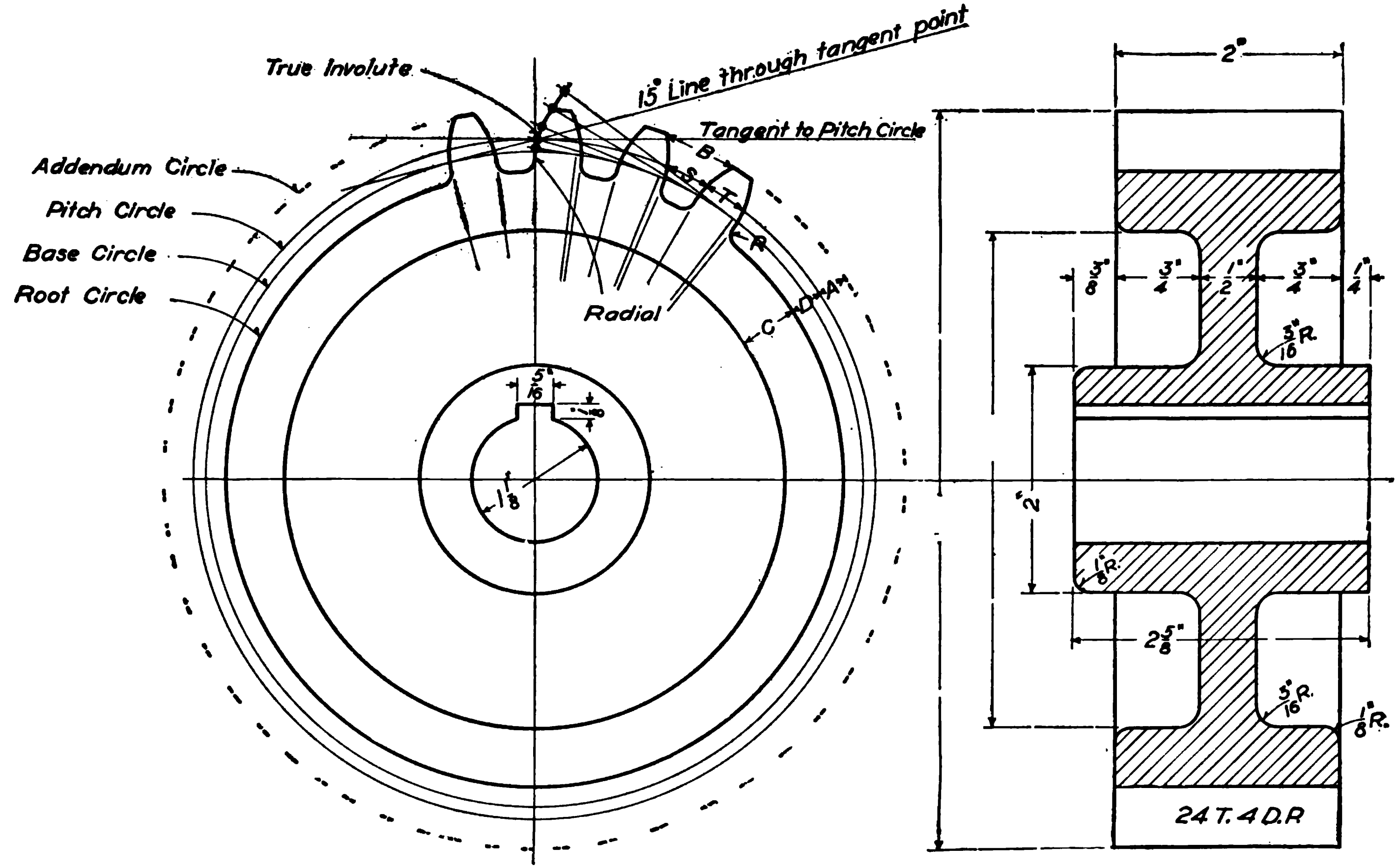
Outside diameter of gear, or diameter of blank, = number of teeth in gear + 2 ÷ D.P.

The particular involute curve most generally used in gear teeth is called the 15° involute. To construct it: Describe the pitch circle of the required gear and draw a line tangent to it. At the tangent point, draw a line at an angle of 15° to the tangent line. From the center of pitch circle, draw a circle tangent to the 15° line; this is called the base circle, and is the circle upon which the involute is generated.

When laying out the gear teeth, observe that the part of the tooth inside of the base circle, or the *flank*, as it is generally termed, is a radial line. It is necessary to lay out the involute curve but once, for the student may set his compasses to a radius (which will be an approximation to this curve), to throw in the faces of the other teeth. This work requires the utmost care to obtain accurate results.

When pencil drawing is complete, make a good clear tracing.

Where the dimensions are not shown, the student is expected to use the formulas given to obtain the necessary figures.




SPUR GEAR

CLASS *Industrial*

NAME *John W. Roberts* DATE *Mar. 20-07.*

SCALE *Full Size* DWG. No. C.1020

# LESSON No. 26.

SPECIFICATION.—This lesson is for the purpose of helping the student to develop the faculty of making *mental pictures*, to force him to make a drawing of something not shown, but for which it is necessary for him to use his imagination.

From the following data make a half-size two-view mechanical drawing of the cast-iron pulley described. For the sectional view use the conventional method described in Lesson No. 17 on the hand wheel.

Diameter of the pulley 1 foot 2 inches at the crown (or greatest diameter); face or width 6 inches; taper of crown equals $\frac{1}{4}$ inch per foot.

Diameter of hub $3\frac{3}{4}$ inches; length of hub 4 inches; bore $1\frac{7}{8}$ inches; with keyway $\frac{7}{16}$ inch wide by $\frac{3}{16}$ inch high.

Rim to be made with rib around inside where joined to arms. Rim $\frac{1}{4}$ inch thick at edge, and $\frac{9}{16}$ inch thick through crown and rib; inside of rim to be straight to arms.

Number of arms 6; arms to be $1\frac{1}{4}$ inches wide by $\frac{5}{8}$ inch thick at rim, and $1\frac{5}{8}$ inches wide by $\frac{13}{16}$ inch thick at hub; $\frac{1}{4}$-inch fillets (or rounded corners) at side of arms at hub, and at side and edge of arms at the rim; $\frac{3}{8}$-inch radius at the junction of the arms near the hub.

When locating the keyway in the side view showing the end of the hub, be sure to place it central with one of the arms, as this will give a stronger hub section than if the keyway is placed midway between two arms.

The student is expected to first make a freehand sketch of the two views of the pulley. On this sketch he should place all the dimensions given above, and then use the sketch as a guide when laying out the working drawing. It is assumed that the student will try to study out this lesson *without* looking at a model in the shop, so that he may derive the greatest benefit from his efforts. There is no objection to the student examining a model *after* he has finished his freehand sketch to the satisfaction of his instructor.

Make a tracing of the finished pencil drawing, the title to be 14″ Pulley, Drawing C–1021.

Take plenty of time and get all possible from this lesson.

# LESSON No. 27.

CONIC SECTIONS.—The fundamental principle involved in this lesson is the projection of a *point.*

A thorough knowledge of this subject is of great value when drawing pieces of such shape that it is difficult to project correctly the necessary views. From this lesson the student should realize that curves and circular figures may be projected in a very simple manner if taken point by point.

The figures shown on Drawing C-1022 illustrate a cone cut by a plane in two different ways. When a cone is cut by a plane which passes between the apex and the base at any angle except a right angle, the section will be an ellipse. If the cone is cut by a plane which is parallel with one side, the section made is a parabola.

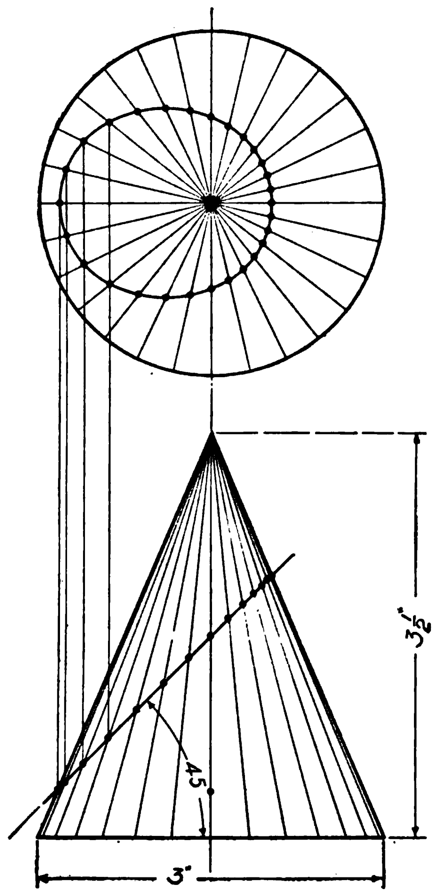
Lay out the cones to the dimensions given. Divide the base circle of the top view into any number of points equally or unequally spaced; from these points draw lines to the apex; now project the lines down onto the side view.

To develop the ellipse, cut the cone as shown; the points made by the intersection of the cutting plane with the slope lines should then be projected to the *same lines* in the top view. By connecting these points we have a true ellipse.

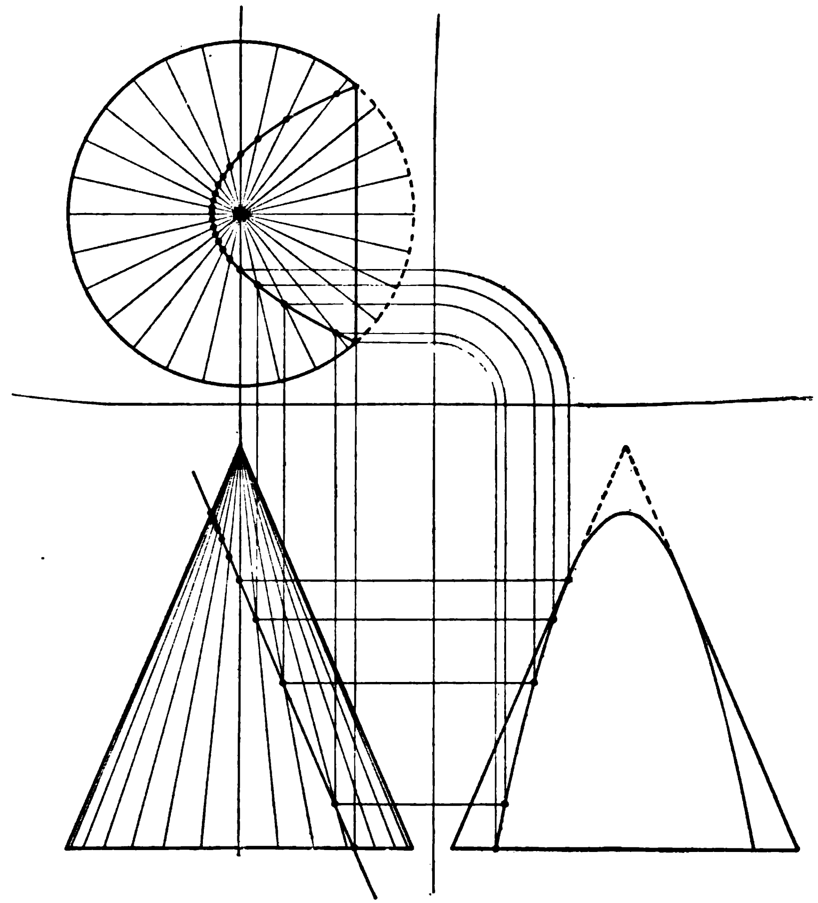
The top view of the parabola is projected in the same manner as the ellipse. With the top and side views complete, it is quite a simple matter to develop the front view point by point, as shown in the illustration.

By this method of projection the student can easily lay out the parabolic curve in the front view first, and then draw the cone around the curve.

Do this work very carefully, as one of the valuable points to be gained from this lesson is the ability to do *accurate* work.




Ellipse



Parabola

CONIC SECTIONS

CLASS Industrial

NAME John W. Roberts . DATE Mar. 28_07.

SCALE Full Size DWG. NO. C-1022

# LESSON No. 28.

INTERSECTIONS.—The important principle contained in this lesson is the projection of a *point.*

From Drawing C–1023, make a full-size pencil drawing of the intersecting cylinders and their developments.

The curve formed by the intersection of the two cylinders is found point by point as shown by points 2 and 4 on the illustration. The oval shown in the end view is formed by cutting the large cylinder off at an angle of 30° with the horizontal plane; it is found in the same manner as the curve of intersection.

If the student studies the illustration carefully, he should be able to follow out the method of projecting a point from one view to another.

As the end views of the cylinders are the only views on which the true circumference can be obtained, it naturally follows that it is the end view in each case that should be used to locate the division points.

The circumference of the cylinder may be divided into any number of points, and those points projected upon the other views to obtain the desired curves.

DEVELOPMENT.—The student should try to realize that a surface is composed of a series of lines.

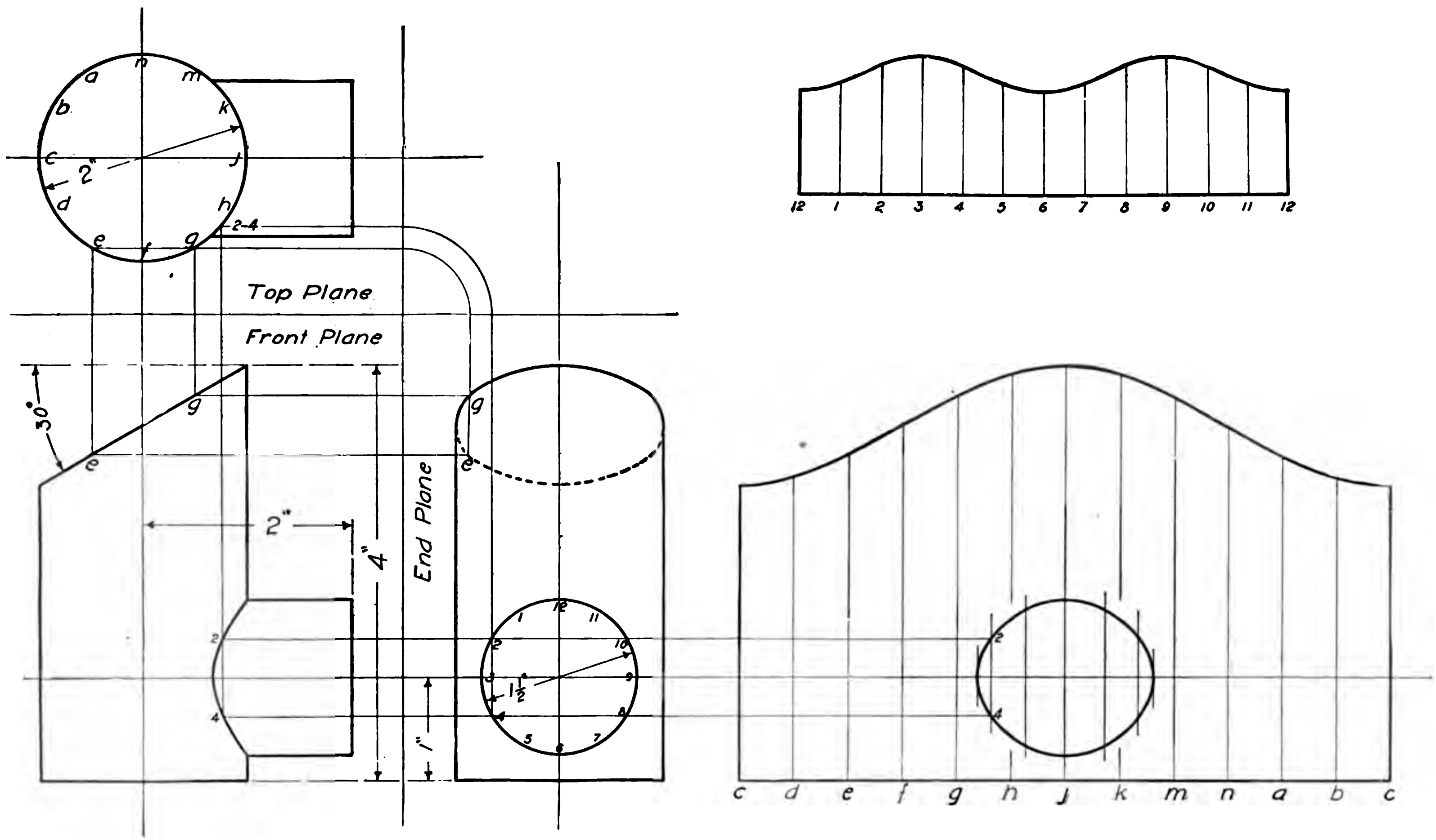
The different methods of developing a surface are usually described by the kinds of lines used for this purpose. As an instance, in our present lesson we use *parallel* lines to develop the surfaces of the cylinders.

If we were to cut the large cylinder through at point C, and were then to spread it out flat, we would have a duplicate of the development of the large cylinder shown.

For the reasons given above, the end view of the cylinder is the proper place to obtain the true length of the development, assuming that the student is unable to find the circumference by simple arithmetic.

The lengths of the various lines used in developing the surface of the pattern may be obtained from the side view.

It is very desirable that each student should make a careful study of this subject, as a thorough knowledge of the principle involved will be of value when drawing difficult shapes.




INTERSECTIONS AND DEVELOPMENTS
PARALLEL LINE DEVELOPMENT

CLASS Industrial

NAME John W. Roberts DATE April 20-07.

SCALE Full Size DWG. No. C 1023

# LESSON No. 29.

INTERSECTIONS.—From Drawing C–1024, make a full-size pencil drawing of the intersecting cone and cylinder and their developments.

If the student has fully mastered the previous lesson on intersections, he should be able to develop the curves of intersection shown in the top and front views of the present lesson. These curves are found in the same manner as those of the intersecting cylinders; that is, point by point.

The student may divide the end of the cylinder into any number of points, then draw radial lines through these points. Or he may draw the radial lines first, and then place points at the intersections of the lines with the end of the cylinder, as shown by points 1 and 4.

The latter method is the one used in the illustration, and the student should observe that to project these points 1 and 4, it is *first* necessary to have the radial line 1–4 projected upon the top view.

RADIAL-LINE DEVELOPMENT.—In our last lesson the surfaces of the figures were composed of parallel lines, the method of development being named from the kind of lines used.

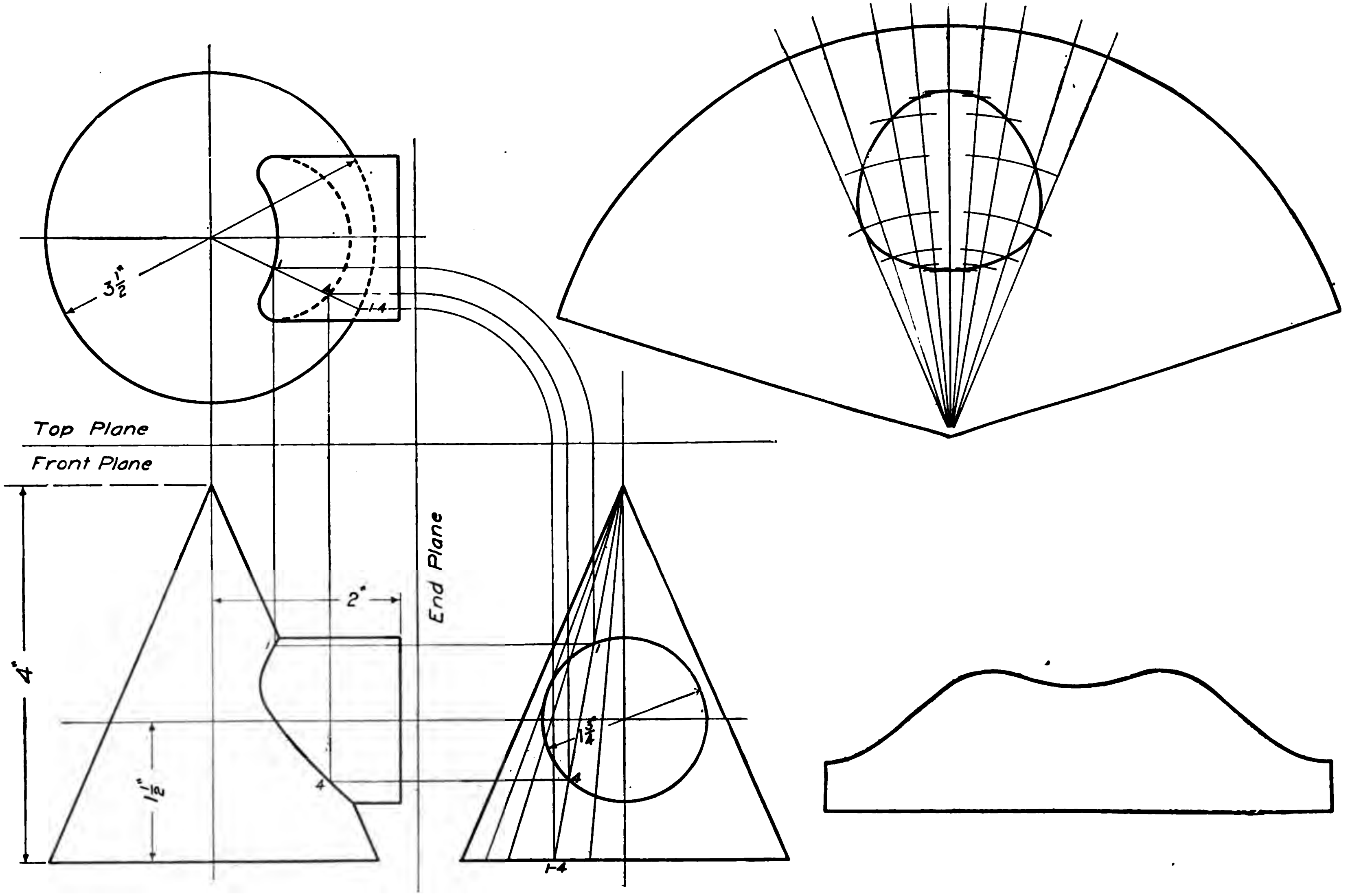
In our present lesson we find it necessary to use radial lines to develop the surface of the cone, from which this method derives the name of "Radial-line Development."

When laying out the development of the cone, the student must bear in mind that the true length of the lines on the cone can be found on the sides of the cone only, as in all other positions the lines are foreshortened. Thus to get the true distance from the apex of the cone to point 1, this point must be projected to one of the sides.

The length of the arc of the development is equal to the circumference of the base of the cone.

The radial lines used in finding the intersections are also used in locating the opening in the development.

Do your work very carefully.




CLASS *Industrial*

NAME *John W. Roberts* DATE *April 26_07.*

INTERSECTIONS AND DEVELOPMENTS
RADIAL LINE DEVELOPMENT

SCALE *Full Size* DWG. NO. C.1024

# LESSON No. 30.

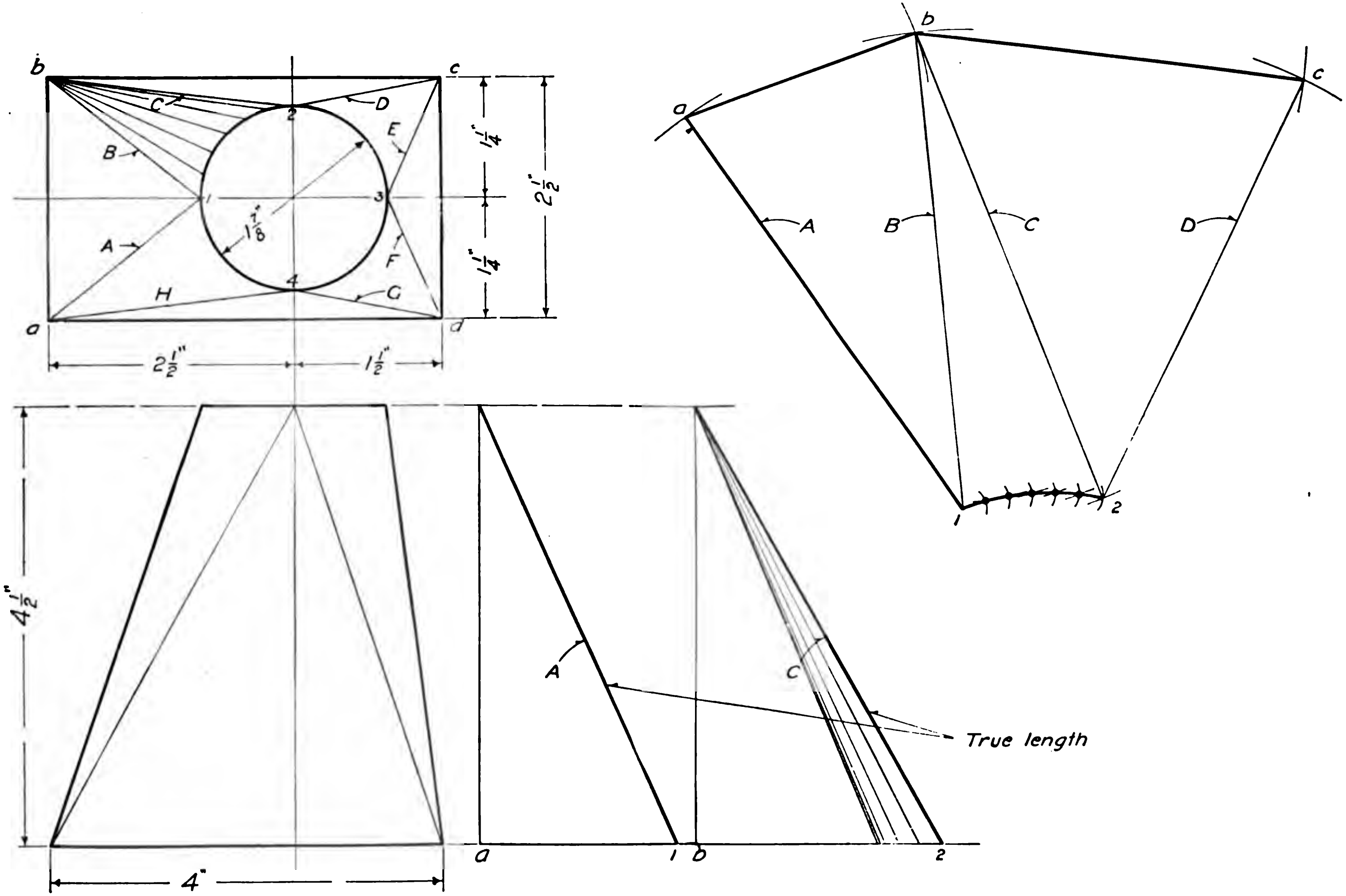
TRIANGULATION DEVELOPMENT.—Upon a B-size sheet of drawing paper (15″×22″), make a full-size pencil drawing of the Transition Piece and its development.

Sheet-metal workers require a great many patterns which cannot be laid out to good advantage by either the Parallel- or Radial-line methods of development.

These patterns may usually be laid out by dividing the surface of the figures into a series of triangles, from which this method gets the name "Triangulation Development."

LESSON.—First lay out the two views of the piece illustrated, marking them with letters and figures as shown. Then find the true length of each of the slope lines ABCD, etc. These lengths may be found in the manner indicated on the illustration, which the student should be able to understand without help.

Now, using these lines with the top and base lines, construct the triangles into which the figure had been previously divided. Connect these triangles in the manner indicated by the partial development, and the result will be the complete pattern desired.




CLASS *Industrial*

NAME *John W. Roberts* DATE *May 6_07.*

INTERSECTIONS AND DEVELOPMENTS
TRIANGULATION DEVELOPMENT

SCALE *Full Size* DWG. NO. *B_1025*

# LESSON No. 31.

SPECIFICATION.—This lesson, like Lesson No. 26, is intended to strengthen the student's faculty for mental picturing, and to give him confidence when working from a written description or specification. Another object is to help the student to become more familiar with the rules for laying out spur gears.

The student may refer to Lesson No. 25 if he has forgotten the rules for spur gearing; he should study these rules carefully, as a thorough knowledge of this subject should prove of great value.

From the following data make a half-size pencil drawing and tracing of a 15° involute spur gear.

The gear to have 28 T., 2 D.P. Face or width $3\frac{1}{2}$ inches. Hub central with face, with 2-inch bore, $3\frac{1}{2}$-inch diameter, and 5 inches long. Keyway $\frac{1}{2}$ inch wide by $\frac{3}{16}$ inch high. Web, or part connecting hub with rim, to be $\frac{3}{4}$ inch thick and central with face. $\frac{1}{4}$-inch fillets at junction of web with hub, and of web with rim. Round inside edges of rim with $\frac{3}{16}$-inch radius. Hub to have sharp corners.

The student should first make a freehand sketch of a sectional view of the gear. On this sketch place all the dimensions given above. Now calculate all the necessary dimensions which are not given, such as diameter of pitch circle, blank diameter, circular pitch, etc.

All students are expected to do their work in a methodical manner, first making the sketch and the calculations, and then working from both to make the finished working drawing.

It is a valuable faculty to learn to be systematic in all your work, as much valuable time will be saved to your employer, and fewer mistakes will be made.

The title of this drawing is "Spur Gear," Drawing No. C–1026.

# LESSON No. 32.

BEVEL GEARING.—Gear wheels are constantly used for transmitting motion between shafts. When the axes of the shafts are parallel, spur gears are generally used; it frequently happens, however, that the shafts are not parallel, but are placed at an angle with each other, in which event it is necessary to use a different kind of gear wheel. Bevel gears are well adapted for use under such conditions, as they can be used to good advantage at practically all angles.

When the gears are the same size and the shafts are placed at right angles, they are called "mitre gears," but when one of the wheels is larger than the other, it is described as the "gear," while the smaller is called the "pinion."

In general drafting-room practice it is customary to show only sectional views of bevel gears, as any other views are as a rule unnecessary, and considerable time and expense are thereby saved.

On Drawing C–1027 is shown a sectional view of a gear of 40 T., 4 D.P. in mesh, with a pinion of 20 T., 4 D.P. The student is expected to make an *accurate* pencil drawing and tracing of this subject.

The pitch diameters are found in the same manner as in spur gearing, but are measured at the points indicated on the illustration.

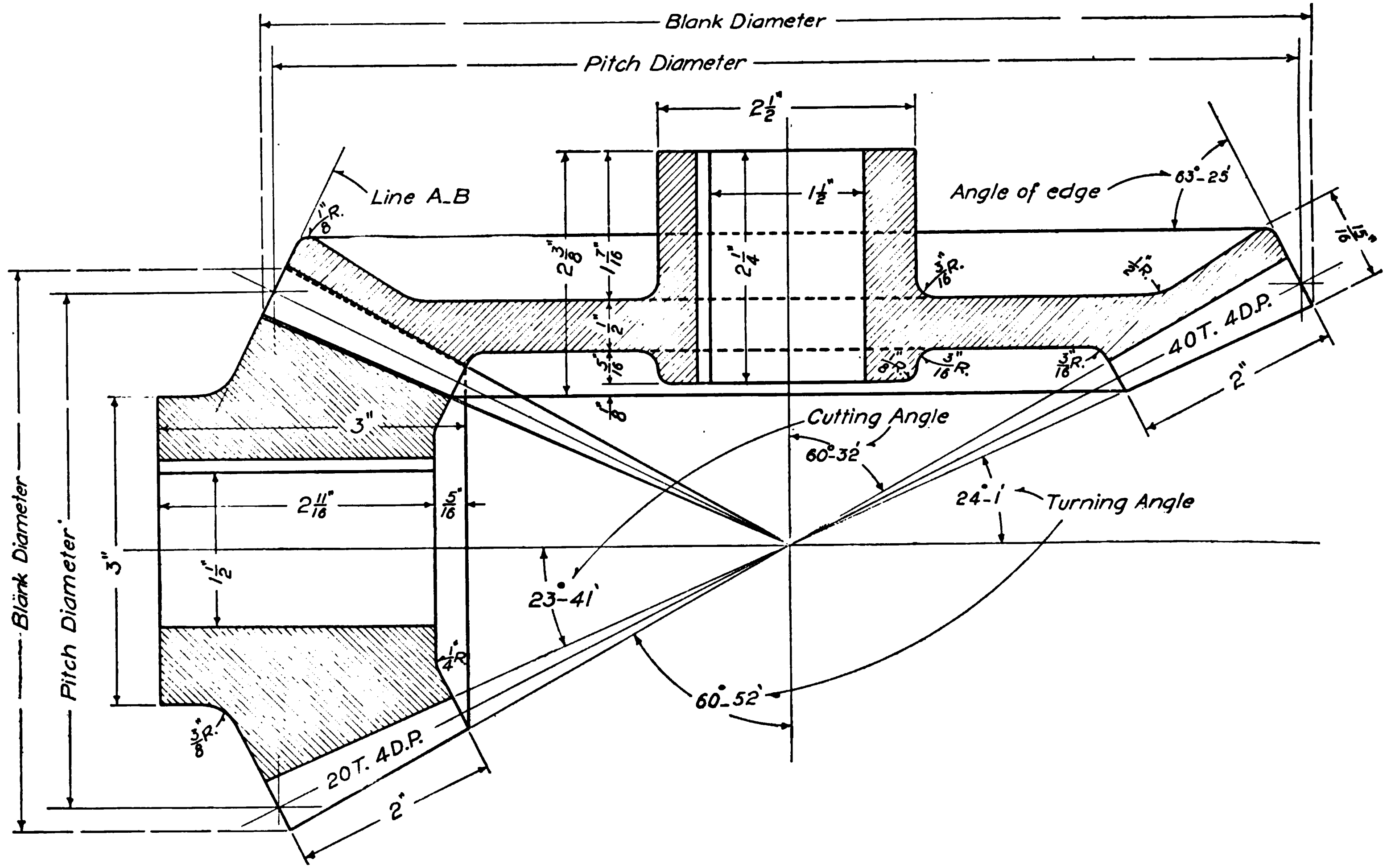
To construct the gear and pinion illustrated: first lay out the center lines, then draw in construction lines representing the pitch diameters. From the intersection of the center lines draw radial lines cutting the intersections of the pitch diameter lines. These radial lines are also pitch lines or neutral lines of the tooth.

The addendum height, depth of land and clearance, are found as in spur gearing, but these measurements are taken along line A–B, which is at right angles with the radial pitch line.

Assuming that the student has no knowledge of the trigonometric functions, or the solution of triangles by plane trigonometry, it is expected that each student will lay out this lesson with *great care*, so that the blank diameters of the gear and pinion may be obtained by scaling the pencil drawing. The various angles, as the turning and cutting angles and angle of edge, may be found in the same manner, using a protractor to measure the angles. Later, when the student has received some instruction in plane trigonometry, he will be required to calculate these diameters as well as the various angles given.

The keyway is $\frac{3}{8}$ inch wide by $\frac{1}{8}$ inch high in both gear and pinion.

Note carefully the method of dimensioning these gears; the draftsman must always keep in mind the needs of the pattern maker and machinist in all his work. He should be familiar with the various shop operations of machining the pieces he illustrates, otherwise it is rather difficult for him to dimension a drawing intelligently.




BEVEL GEARS

CLASS Industrial

NAME John W. Roberts DATE May 12-07.

SCALE Full Size DWG. NO. C-1027

# LESSON No. 33.

ISOMETRIC PROJECTION.—It is frequently necessary for the mechanical draftsman to make one-plane projection drawings of certain forms of construction. If these illustrations are prepared as they would appear from a single viewpoint, they are termed perspective drawings.

Perspective drawings best illustrate this type of work from the fact that they represent the object as it would appear to the eye; at the same time there are certain disadvantages connected with this system. The main objection is that these drawings cannot be laid out from dimensions as mechanical drawings are, and this one disadvantage is quite serious from the point of view of the draftsman.

Isometric, or *equal measure* projection, is a fairly satisfactory substitute for perspective drawing for certain classes of work.

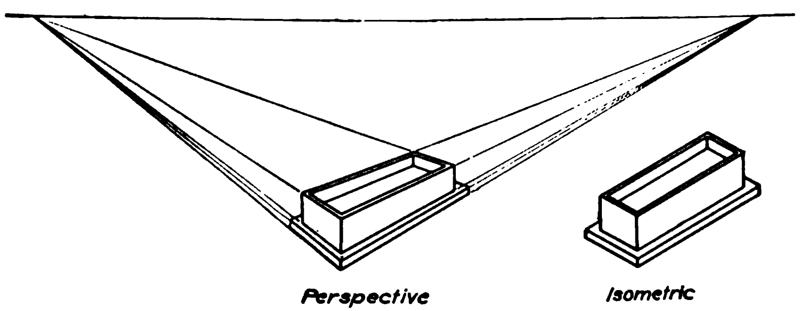



FIG. 20.

This method may be termed approximate perspective, as it represents an object in such fashion that it looks approximately as it would appear to the eye. The primary difference between two drawings of an object, one in perspective and the other in isometric, is that in the perspective drawing the surface lines converge at a certain distance from the object, as shown in Fig. 20, while in the isometric drawing these same surface lines are parallel.

For certain shapes, or at least for some views, isometric drawings are not satisfactory, as the figure appears badly distorted and unpleasing to the eye, but for most subjects it will be found quite satisfactory.

Isometric Projection is based on the theory that the object is

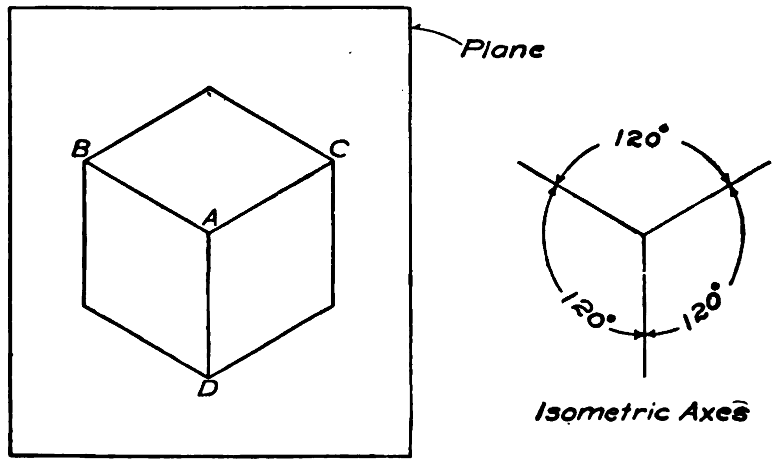



FIG. 21.

viewed through a plane with which certain main features of the body are equally foreshortened. To illustrate, the cube shown in Fig. 21 is tilted forward until the edges A–B, A–C, and A–D are equally foreshortened as seen through the plane.

This figure also illustrates what are known as the Isometric Axes and their origin, as these three edges of the cube (A–B, A–C, and A–D) considered as lines, are separated by an equal angular

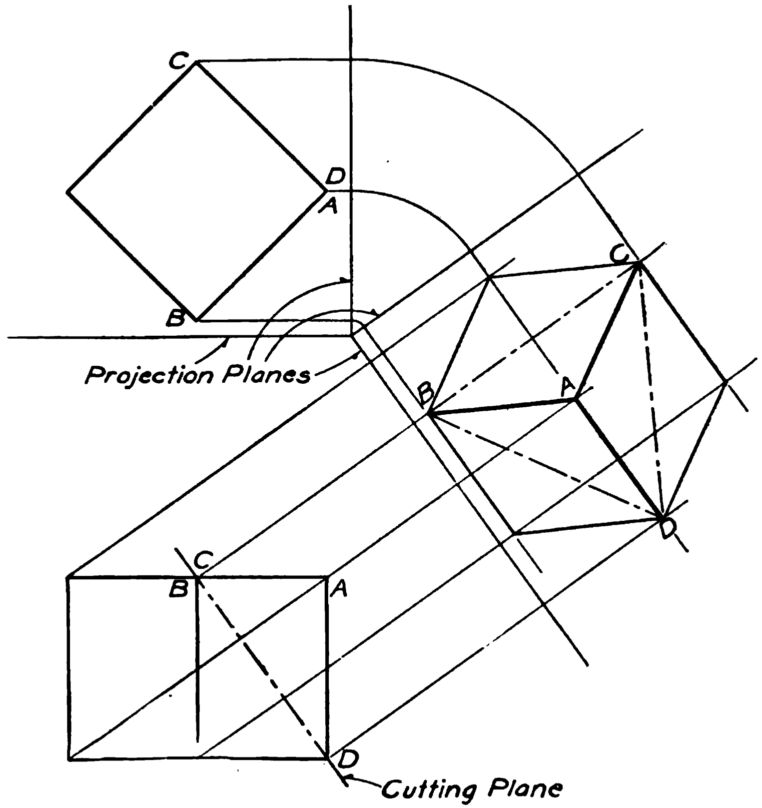



FIG. 22.

space and correspond to the three dimensions, length, breadth, and height.

Fig. 22 represents a two-view mechanical drawing of a cube, from which is projected (orthographically), an isometric view of the cube. This illustration shows the transformation from mechanical to isometric, the relationship between these two methods, and makes clear the sound basis from which isometric projection is derived.

To demonstrate the theory that the surfaces of the body are equally foreshortened, we place the cutting plane through points B, C and D of the cube, then as the projection plane is located parallel with the cutting plane, the portion of the cube cut away (as indicated by the dash lines in the isometric view) forms a triangular pyramid with corners of equal length.

The student should try to remember the following fundamental principles of isometric projection:

There are three basic lines known as isometric axes;

Isometric axes are separated by an equal angular space, and correspond to the dimensions, length, breadth and height;

Vertical lines on the object are vertical lines on the drawing. Lines parallel on the object are parallel on the drawing. Right angles on the object are either 60° or 120° on the drawing;

Lines not parallel to one of the isometric axes are termed non-isometric lines. Measurements may be made only on isometric lines.

ISOMETRIC DRAWING.—When a drawing has been made according to the rules of isometric *projection*, the isometric lines forming this drawing are eighty-one hundredths (.81) of their true length. As this necessitates using an isometric scale, it is generally considered good practice to use an ordinary scale and to lay out the figure to the dimensions given. The result will be an isometric *drawing*, not a projection, but as the only difference is in the *size* of the figure, this is of little importance.

COORDINATE AXES.—When laying out isometric drawings of certain shapes, a very convenient aid is the related axes, usually termed coordinate axes. Fig. 23 illustrates this feature, as it shows how the isometric view of a triangular pyramid

may be constructed with the aid of these axes and the mechanical views.

To construct Fig. 23, lay out the mechanical views as shown,

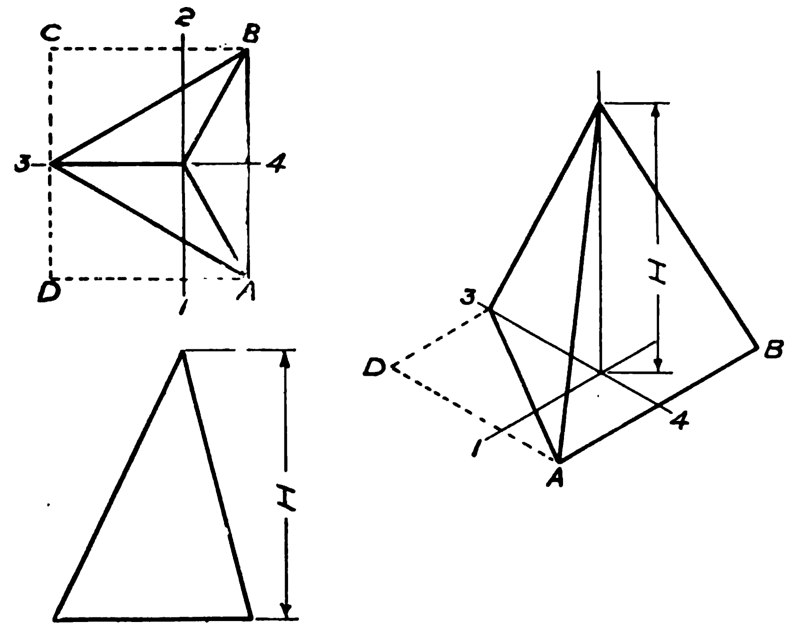



FIG. 23.

then draw a rectangular figure about the top view (as indicated by ABCD). This gives a figure that parallels the isometric axes and on which we may locate the base of the pyramid. After this has been done, find the point of intersection of the axes (1–2 and 3–4) on this figure, and from this point erect a perpendicular on which lay off the height of the pyramid. Now connect the apex point with the corners on the base and the figure is complete.

To emphasize the convenience of these related axes, the student is reminded that measurements may be made only on isometric lines, and as the lines forming the outline of the pyramid base are not at right angles with each other, only one side may be placed on an isometric axis.

Fig. 24 shows the application of the coordinate axes to quite a differently shaped figure from our last illustration. The mechan-

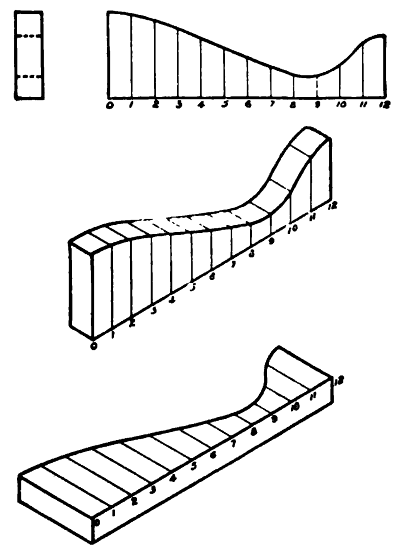


FIG. 24.

ical view of the side of the piece is divided into a certain number of parts (any number), spaced either evenly or unevenly, then these lines or axes are used as shown when constructing the isometric view. Two applications are shown, one of which is pleasing to the eye, and the other quite the reverse.

ISOMETRIC CIRCLES.—The methods of constructing isometric circles should require little explanation and their application

to rounded corners should be readily understood from the illustration, Fig. 25.

For general purposes the four-center method will be found satisfactory, and, with a little study of the illustration, the student should be able to apply this method to his work.

One feature which it is well for the student to bear in mind is

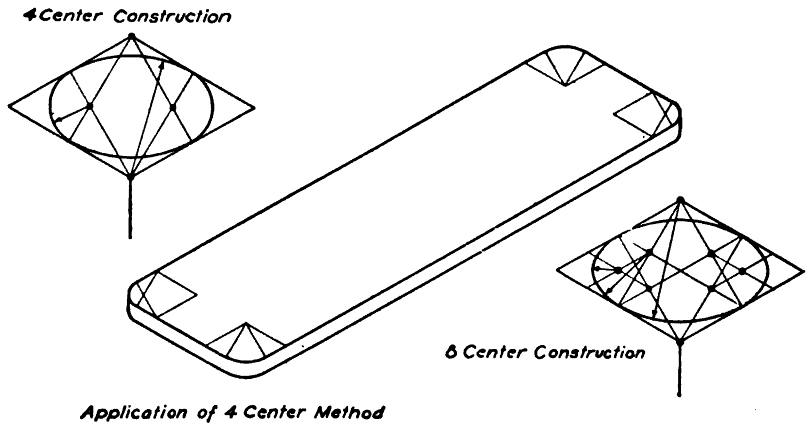



FIG. 25.

that to construct any circle arc, he should lay out an isometric square of the *circle diameter*, as a means of locating the position of the radius center.

BROOM HOLDER.—Fig. 26 shows a two-view mechanical drawing of a broom holder. From this illustration the student is expected to lay out a full-size isometric drawing of the figure. No hidden surfaces need be shown, as this is seldom done in drawings of this nature. The title is to be "Broom Holder, Drawing C–1028."

The student is expected to lay out a view which shows the top,

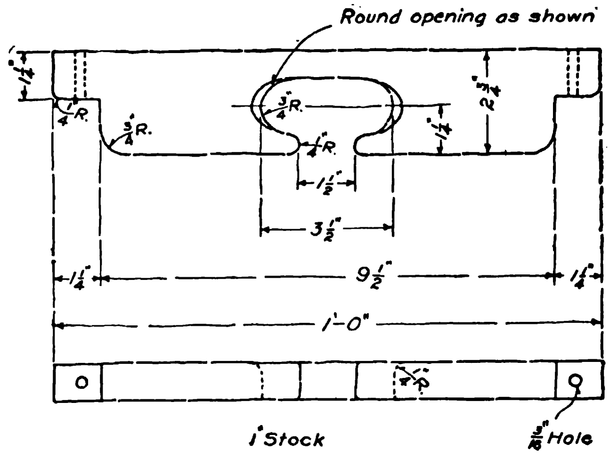



FIG. 26.

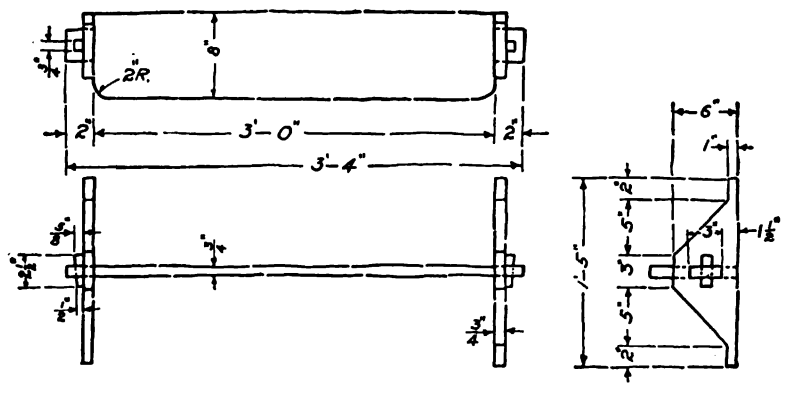


FIG. 27.

the front, and the left-hand end, as this view will be most pleasing to the eye. Do not overlook the small screw-holes near the ends, as they should be shown.

No dimensions need be placed upon any of these isometric drawings unless for some special reason the teacher may desire it.

WALL SHELF.—On Fig. 27 is shown a three-view mechanical drawing of a wall shelf. From the information given the student is expected to lay out a quarter-size isometric drawing of the object. Show no hidden surfaces, but draw in all parts which would be in sight naturally from a single view-point.

The same view suggested for the broom holder will be found to be satisfactory, that is, one showing the top, the front and the left-hand end.

To lay out this drawing correctly will require careful workmanship, and the student will find that this subject offers several opportunities for making mistakes if he fails to keep in mind the principles of isometric drawing.

The title of this lesson is "Wall Shelf, Drawing C-1029."

# LESSON No. 34.

VALUE OF PRACTICE.—From the previous lessons the student should have become familiar with the general principles of mechanical drawing. With this assumption in mind, the main requirement of the student is now to obtain sufficient practice, making detail and assembly drawings, to help him to become proficient in turning out rapidly work that is accurate, with the lettering and dimensioning done in a neat and attractive manner.

No modern drafting room will send out blue prints of drawings upon which the lettering has been poorly done, or the dimensions of which are indistinct. Many a young draftsman has been refused employment simply because he was a poor letterer. If the applicant's sample drawing is neatly lettered and dimensioned, the chances are that he will be given an opportunity to show what he can do.

The student is expected to do the very *best* work he is capable of, on the following working drawings.

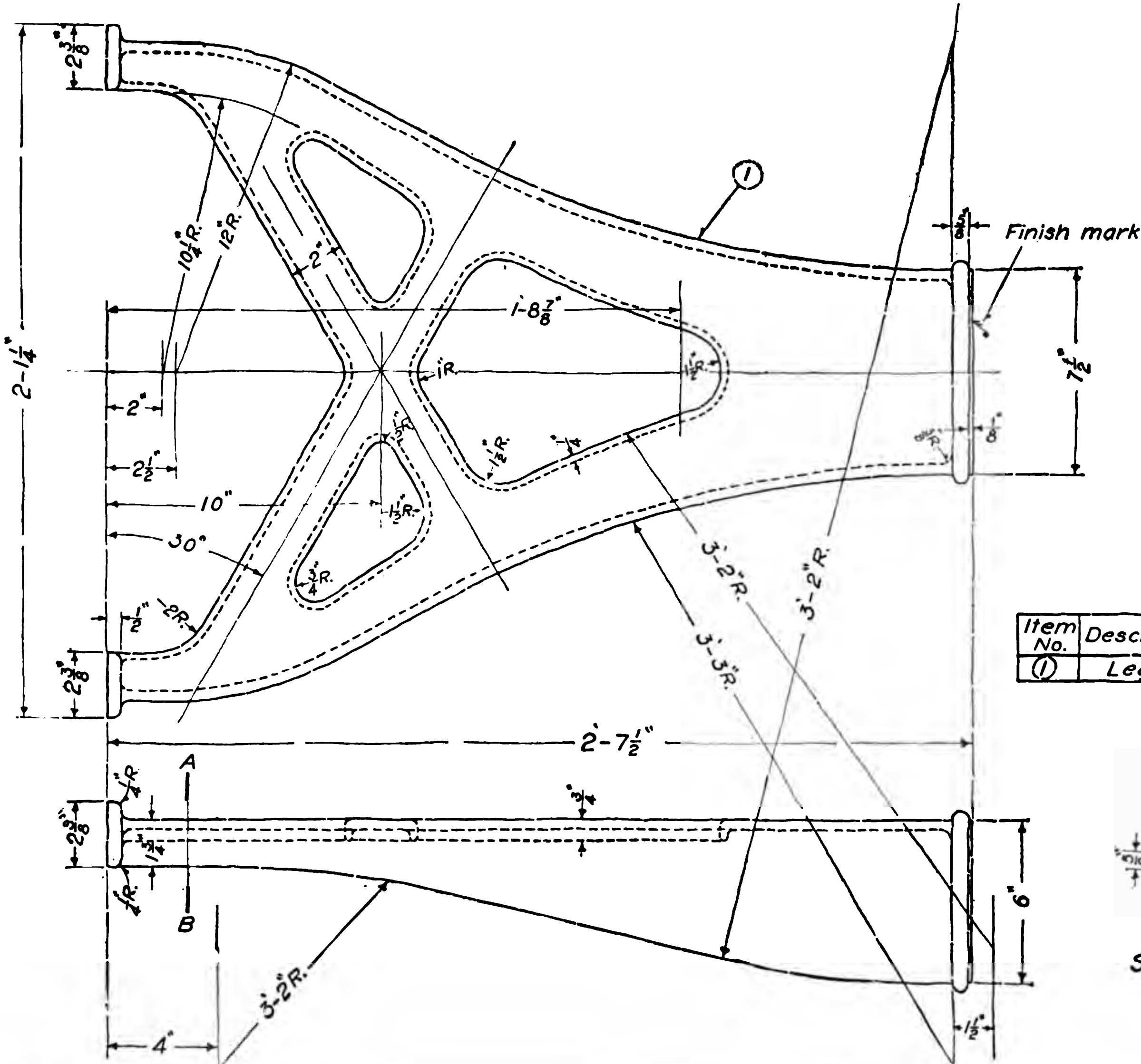
DETAIL DRAWING.—The present lesson is a quarter-size detail drawing of the lathe leg shown on Drawing C–1030. Make a tracing of the finished pencil drawing.

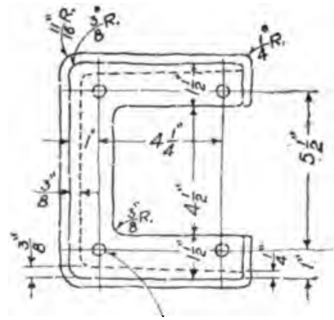
The student will observe that the metal of the side of the leg is $\frac{3}{8}$ inch thick near the back, and that it tapers down to $\frac{1}{4}$ inch at the front edge. This is shown in the top view, and is for two purposes: To make the casting light but strong, and also to allow the pattern to be easily lifted out of the sand when making molds in the foundry.

The openings in the back of the leg are for the purpose of making the casting lighter. The $\frac{1}{4}$-inch rib around these openings strengthens the casting without adding much weight.

To throw in the large radii given, the student will find it necessary to use a beam compass, as these radii are too long for the ordinary compass, even though the extension bar were used.

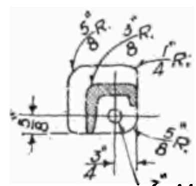
In most drafting rooms a mark of some kind is used on the drawings to indicate that a surface is to be finished, that is, machined in the shop. The "finish mark" shown on the present lesson is adopted from the Universal Dictionary of Mechanical Drawing by Prof. G. H. Follows.




## BILL OF MATERIAL

| Item No. | Description and Material | Pat. No. | Req. |
|---|---|---|---|
| 1 | Leg C.I. | 70 | 2 |




Section A-B

CLASS *Industrial*

NAME John W. Roberts DATE May 8-07.

12" SPEED LATHE
LEG DETAILS

SCALE ½ Size DWG. No. C.1030

# LESSON No. 35.

LATHE BED.—Make a half-size pencil drawing of the lathe bed shown on drawing C–1031. Make a tracing of the finished pencil drawing.

This drawing shows the method commonly used to take care of pieces which are too large for standard-size sheets; this method is to show the piece "broken," as it is termed.

The lathe bed shown is five feet long, and to show it without "breaking," or the complete bed, would necessitate that it be drawn to a very small scale, so small, in fact, that the views would not show to the best advantage what the drawing was intended to show.

By breaking away part of the bed, we are able to draw it to a larger scale and show more clearly its shape and size. The part broken away is of no value to any one using the drawing, as it is similar to the rest of the bed adjoining the break.

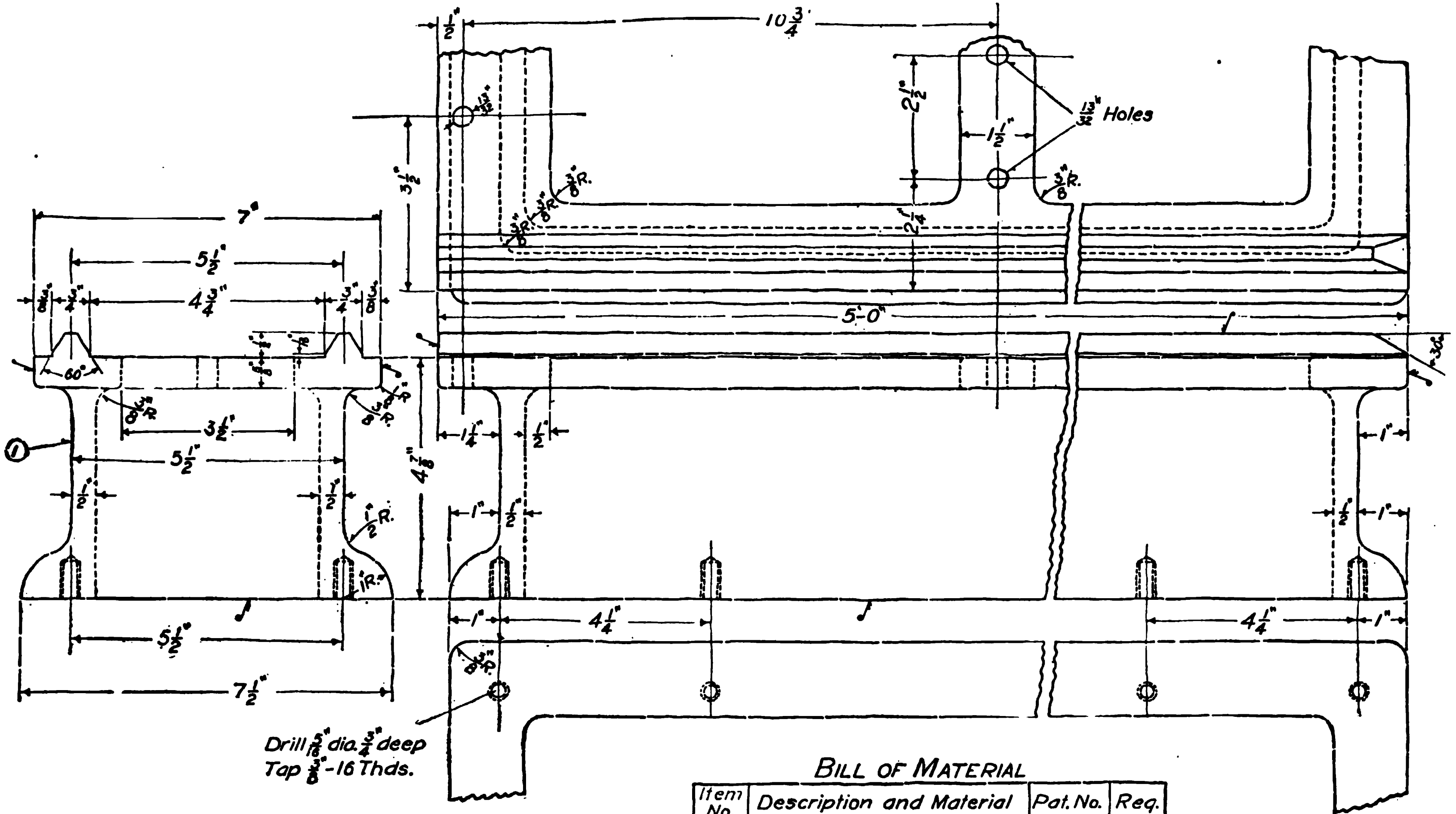
Observe carefully all notes and dimensions, and see that none are overlooked, as full information must be furnished on working drawings.

The cap screws referred to in the "Bill of Material" are for bolting the legs to the bed.

The broken views of the top and bottom of the bed are intended to show more clearly the shape of the corners, the sizes of fillets, and to show the position of bolt holes.

The student should refer to the leg drawing, C–1030, if he desires to see whether the positions of the clearance holes in the top view of the leg correspond to the tapped holes in the bottom of the bed.

Observe the method of using the "finish mark" shown at the top of the end view. This indicates that the whole surface between marks is to be finished.




## BILL OF MATERIAL

| Item No. | Description and Material | Pat. No. | Req. |
|---|---|---|---|
| ① | Bed C.I. | 71 | 1 |
| ② | 3/8"X1 1/4" Hex. Hd. Cap Sc. | | 8 |

**12" SPEED LATHE**
**BED DETAILS**

CLASS Industrial

NAME John W. Roberts DATE May 10-07.

SCALE 1/2 Size DWG. NO. C.1031

# LESSON No. 36.

TOOL-REST DETAILS. — Most of the parts or details of a speed-lathe tool rest are shown on Drawing C–1032; part of these details are drawn half size, and the rest full size.

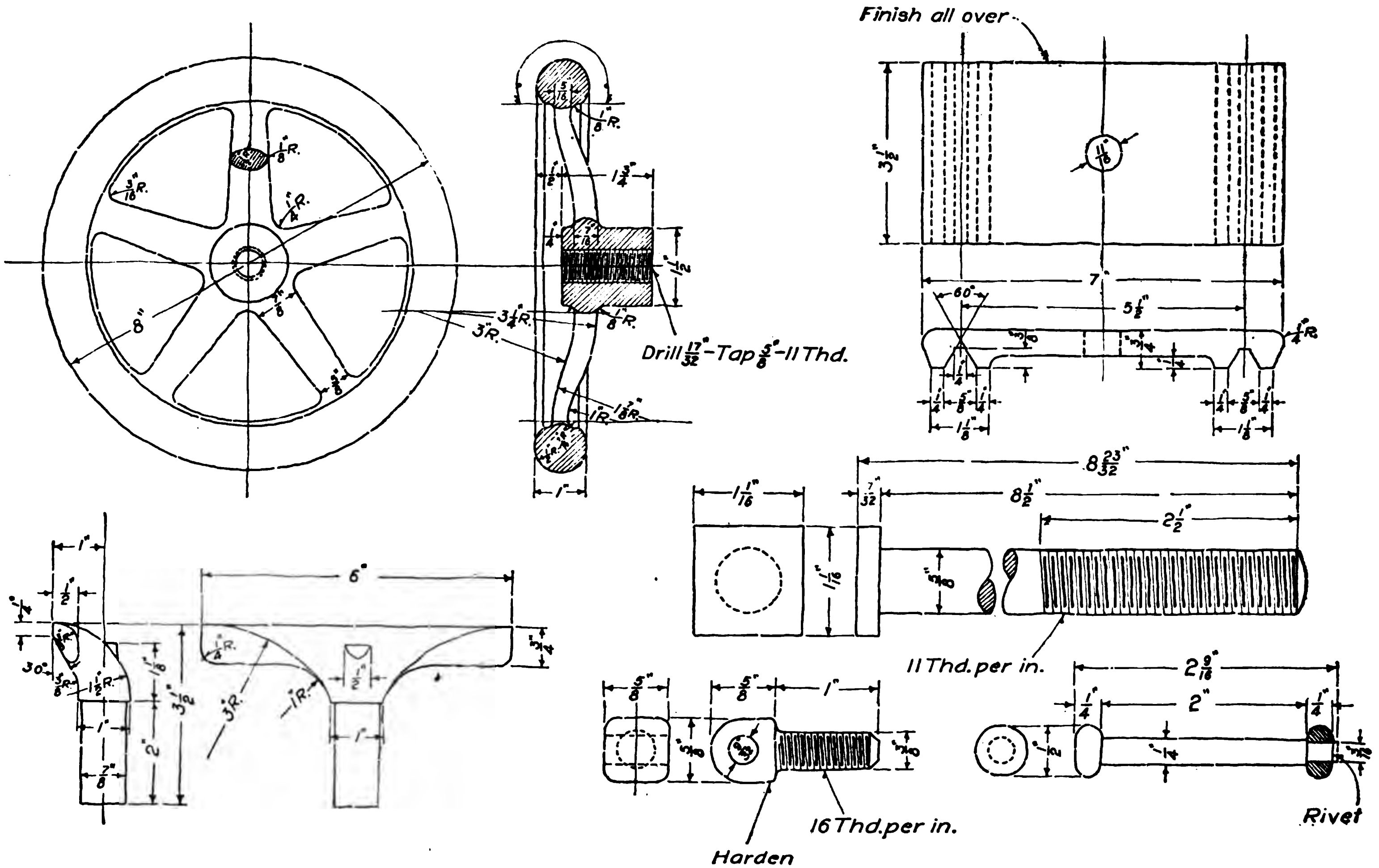
Make an accurate pencil drawing and tracing of the details shown.

The hand wheel is very similar to one drawn in an earlier lesson, with the exception that it is an "offset" wheel, that is, the rim is not central over the arms, but set to one side. The necessary radii with the location of their centers are shown, so that the student should be able to draw this hand wheel without difficulty.

When drawing the arms of the hand wheel, bear in mind what was said in the earlier hand-wheel lesson, in regard to using a straight line for the purpose of joining two curves.

Do not overlook any of the dimensions on the various details, for you must remember that you are furnishing the man in the shop with the necessary information to machine these parts correctly.

Use great care with the lettering and figures.




CLASS Industrial

NAME John W. Roberts DATE Dec. 12_07.

12" SPEED LATHE
TOOL REST DETAILS

SCALE 1/2 & Full Size DWG. No. C_1032

# LESSON No. 37.

TOOL-REST ASSEMBLY.—Drawing C-1033 is an assembly drawing of the complete tool rest.

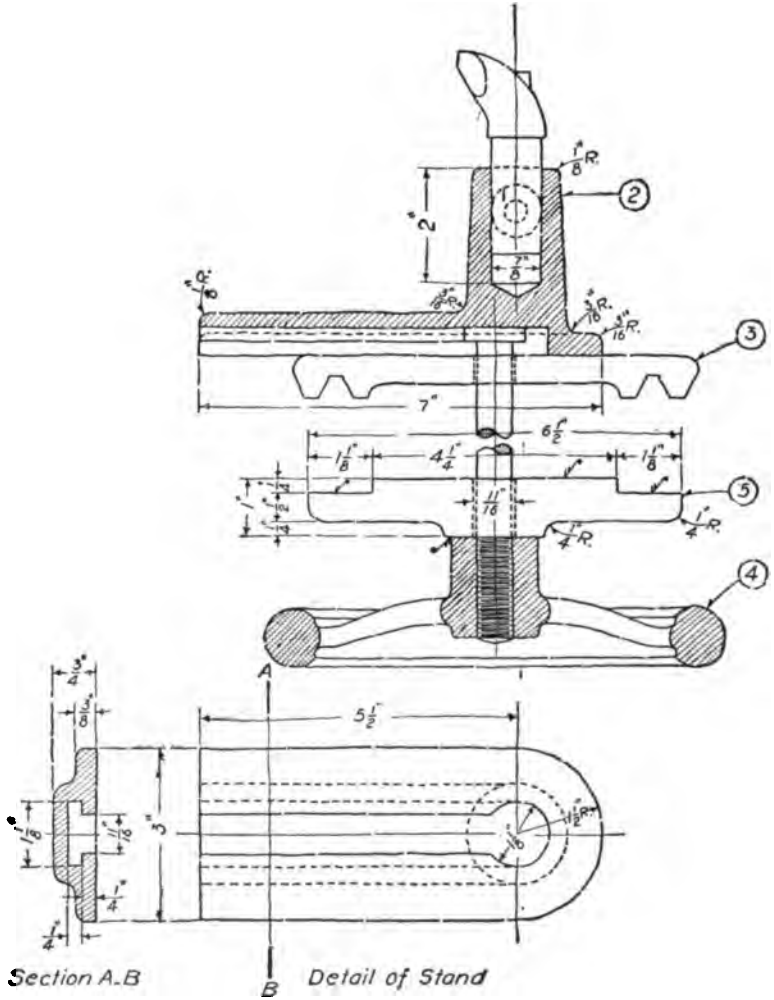
This drawing is used for the purpose of showing how the different parts are fastened together, or assembled, as it is termed.

The only parts dimensioned are the stand and clamp, all of the other details being machined from Drawing C-1032. This assembly drawing is, therefore, used as a detail drawing also, as the stand and clamp may be machined from it.

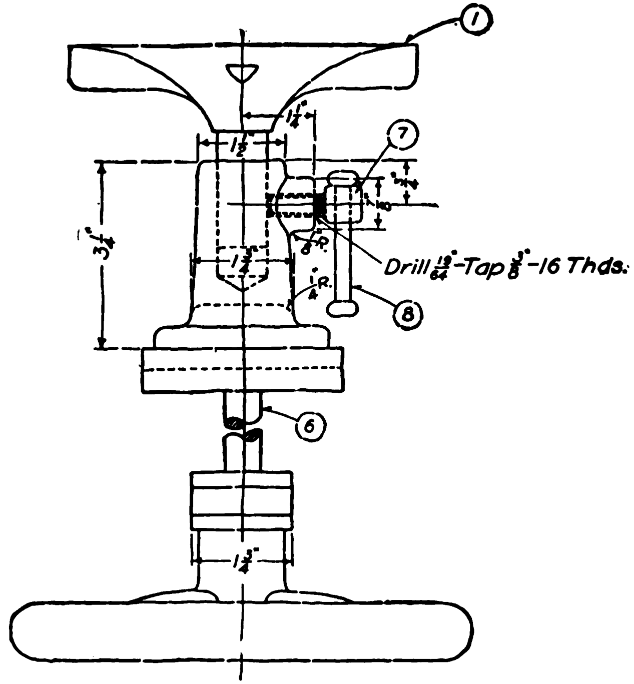
When drawing the parts that are not dimensioned, the student must necessarily refer to the detail drawing to obtain the sizes needed.

Study the drawing carefully so as to obtain a clear understanding of the meaning of each line. Do not simply copy the various lines because they are shown on the original; satisfy yourself as to their meaning.

*Think for yourself.*









## Bill of Material

| Item No. | Description and Material | Pat. No. | Req. |
|---|---|---|---|
| 1 | Tool Rest, C.I. | 79 | 1 |
| 2 | " " Stand, C.I. | 80 | 1 |
| 3 | " " Base, C.I. | 81 | 1 |
| 4 | " " Hand Wheel, C.I. | 82 | 1 |
| 5 | " " Clamp, W.I. | | 1 |
| 6 | Clamp Bolt, W.I. | | 1 |
| 7 | Adjusting Screw, C.R. | | 1 |
| 8 | Adj. Screw Lever, C.R. | | 1 |

CLASS Industrial

NAME John W. Roberts DATE Dec. 24-07.

12" SPEED LATHE
TOOL REST ASSEMBLY

SCALE 1/2 Size DWG. No. C-1033

# LESSON No. 38.

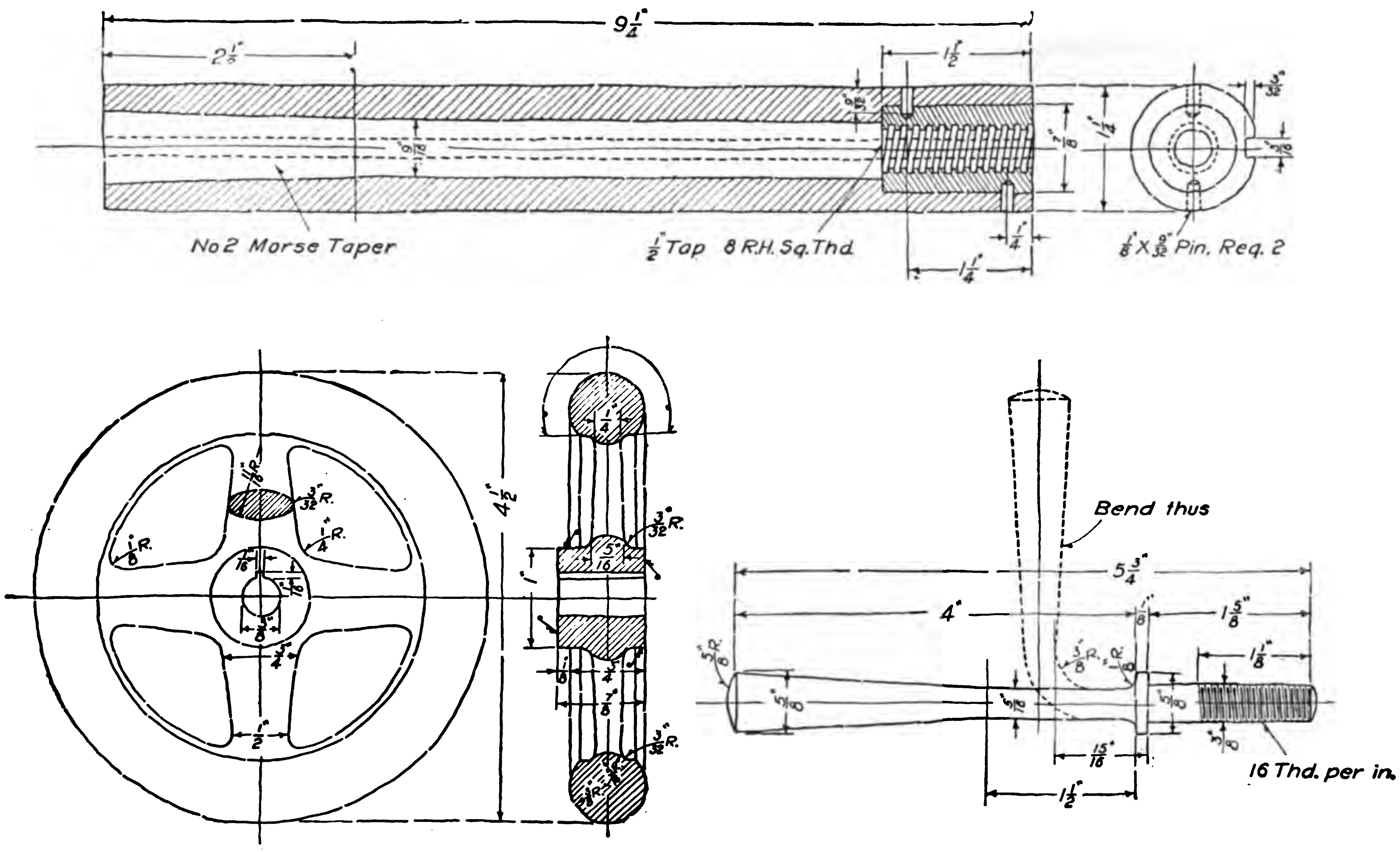
TAILSTOCK DETAILS.—Part of the details of a lathe tailstock are shown on Drawing C–1034.

The sectional view of the spindle shows the taper bore in one end, and the method of fastening the bronze nut in the other end.

The end of the spindle is bored to a taper of approximately $\frac{5}{8}$ inch per foot, or the "Morse Taper," a name by which this particular taper is known in shops and drafting rooms. By a taper of $\frac{5}{8}$ inch per foot, we mean that a cylindrical piece 12 inches long and 1 inch in diameter at the small end will be $1\frac{5}{8}$ inches in diameter at the large end. In other words, the piece is $\frac{5}{8}$ inch larger in diameter at one end than at the other.

By this time the student should be sufficiently familiar with hand wheels to need no instruction on this subject.

The binding screw shown is an illustration which shows the value of a knowledge of shop practice. This screw is machined in a lathe in the manner shown by the solid lines; after being finished, it is placed in a special forming tool, where it is bent to the shape shown by the dash lines. Make a tracing of the finished pencil drawing.




12" SPEED LATHE
TAILSTOCK DETAILS

CLASS Industrial

NAME John W. Roberts DATE Dec. 30_07.

SCALE Full Size DWG. No. C_1034

# LESSON No. 39.

TAILSTOCK DETAILS.—The rest of the details of the lathe tailstock are shown on Drawing C–1035.

The square-thread screw is used to move the spindle in and out of the tailstock barrel. The manner in which the thread is shown on the screw indicates that it is to be cut the full length to the collar. The main object in showing the thread in this manner is to save the draftsman's time.

The small key set into the stem of the screw is known as a Woodruff key. This key resembles a portion of a washer driven into a slot milled in the screw.

The small T-shaped key shown is the spindle key, and is used to prevent the spindle from revolving.

The wrench shown is used to tighten the nut on the clamp bolt, thus fastening the tailstock to the bed.

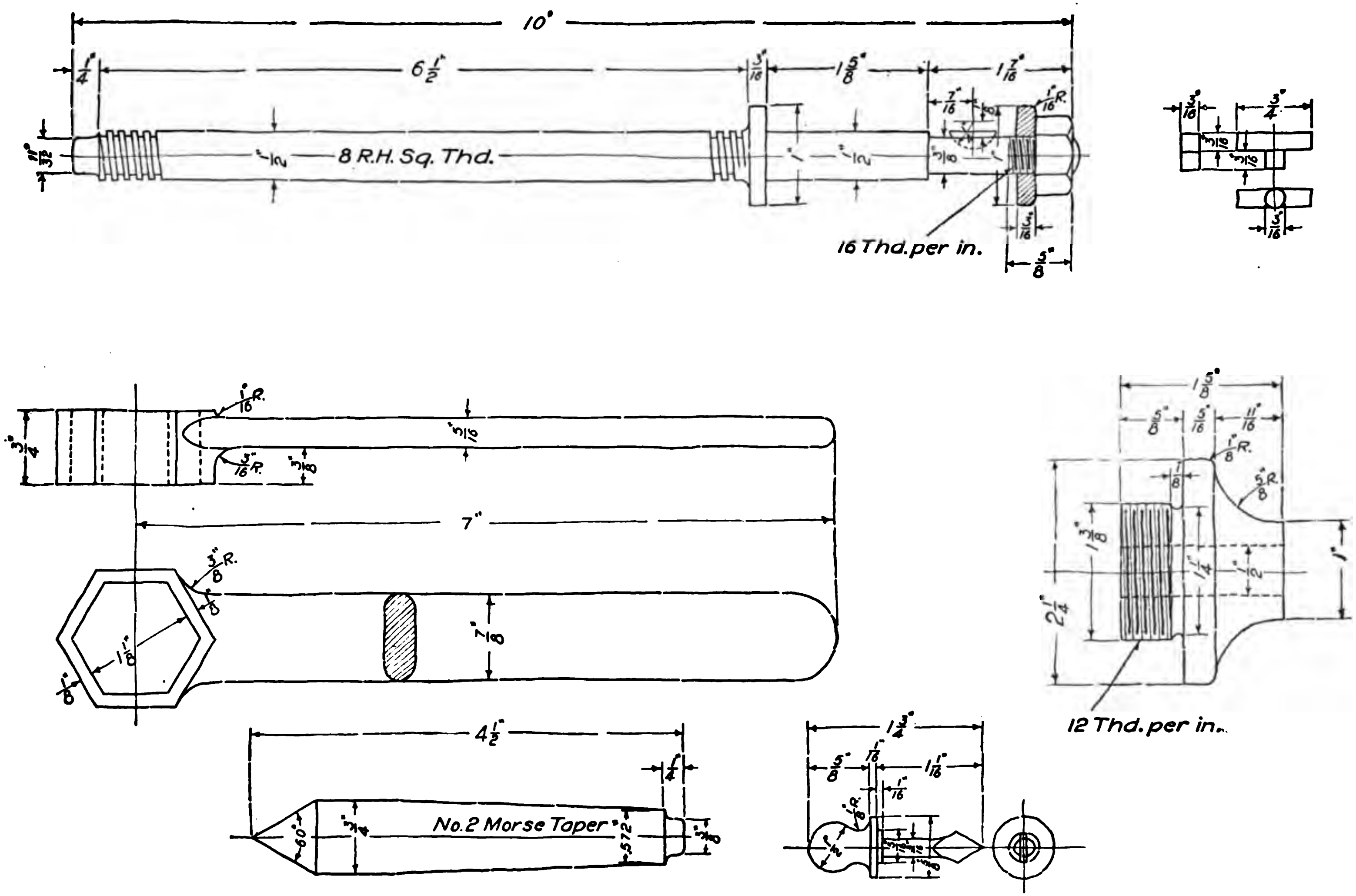
The tailstock plug, or bell as it is usually termed, is screwed into the rear end of the tailstock barrel for the purpose of supporting the spindle screw.

The center illustrated is made of tool steel and hardened. Two of these centers are used on each lathe, one being fitted into the tailstock spindle, the other in the nose of the headstock spindle, the former being known as the "dead center," the latter as the "live center."

The stem of the center is turned to a taper of approximately $\frac{5}{8}$ inch per foot, or what is known as the Morse taper.

The small steel oiler is used to drop oil on the centers.

When making a pencil drawing and tracing of this lesson, do the very best work of which you are capable.




12" SPEED LATHE
TAILSTOCK DETAILS

CLASS Industrial

NAME John W. Roberts DATE Jan. 6-08.

SCALE Full Size DWG. No. C.1035

# LESSON No. 40.

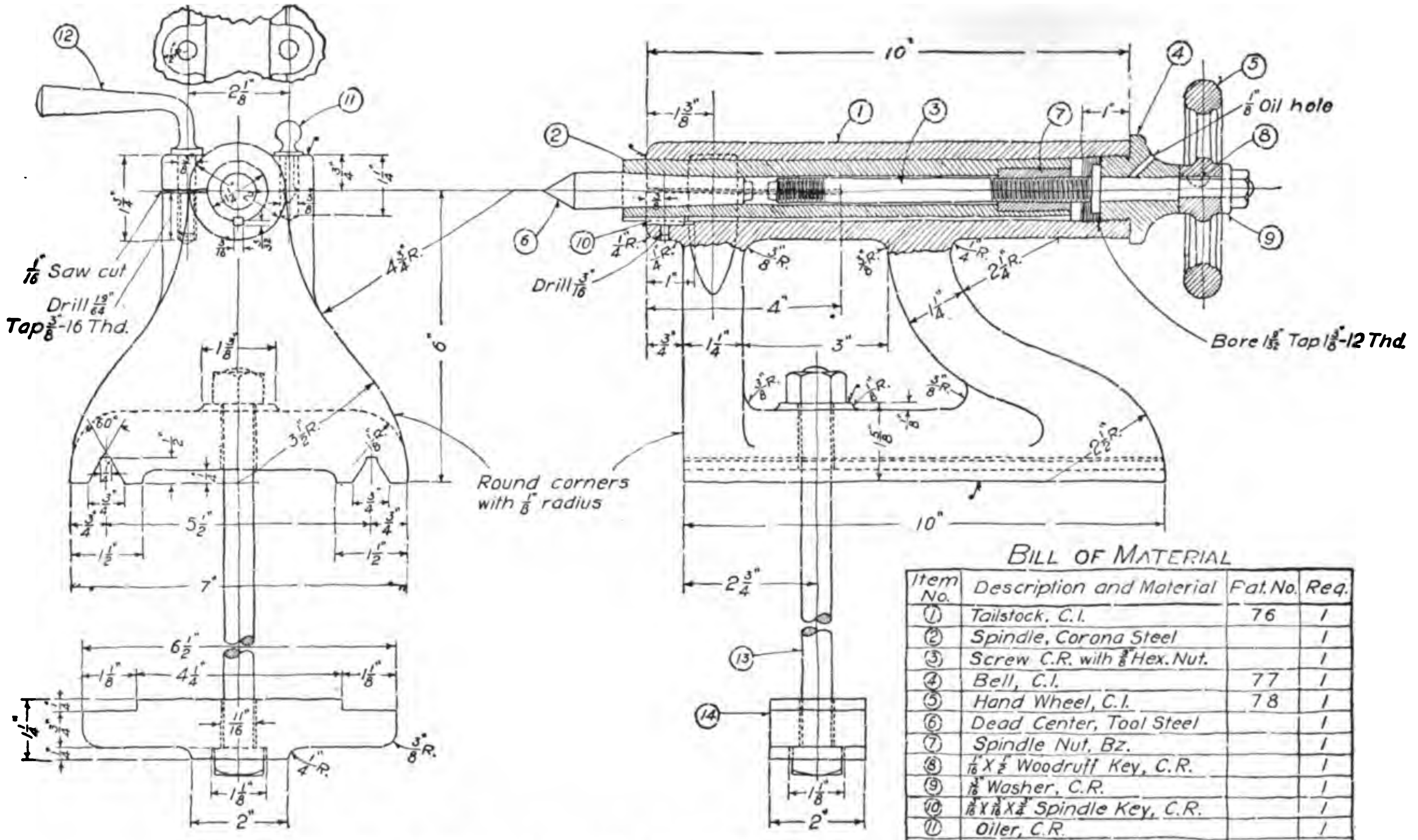
TAILSTOCK ASSEMBLY. — Drawing C–1036 shows the tailstock completely assembled, with all the details numbered to correspond with the numbers in the "Bill of Material."

Where dimensions are not shown on certain parts, the student is expected to refer to the detail drawings for the necessary information.

The saw cut on the side of the tailstock barrel is for the purpose of allowing this part to clamp tightly around the spindle when the binding screw is tightened down.

The oil hole shown in the bell should be drilled after it is in place in the barrel, as it should of necessity be on the upper side of the bell.

Make this drawing and tracing very carefully; do not overlook any dimensions or notes. Bear in mind that nothing is good enough but the best work you are able to do.




Note: For details see Dwgs. C.1034 & C.1035

BILL OF MATERIAL

| Item No. | Description and Material | Pat. No. | Req. |
|---|---|---|---|
| 1 | Tailstock, C.I. | 76 | 1 |
| 2 | Spindle, Corona Steel | | 1 |
| 3 | Screw C.R. with 3/8" Hex. Nut. | | 1 |
| 4 | Bell, C.I. | 77 | 1 |
| 5 | Hand Wheel, C.I. | 78 | 1 |
| 6 | Dead Center, Tool Steel | | 1 |
| 7 | Spindle Nut, Bz. | | 1 |
| 8 | 1/16" X 1/2" Woodruff Key, C.R. | | 1 |
| 9 | 1/2" Washer, C.R. | | 1 |
| 10 | 3/16" X 3/16" X 3/4" Spindle Key, C.R. | | 1 |
| 11 | Oiler, C.R. | | 1 |
| 12 | Binding Screw, C.R. | | 1 |
| 13 | 5/8" X 8" Clamp Bolt with Hex. Nut | | 1 |
| 14 | Clamp, W.I. | | 1 |

CLASS Industrial

NAME John W. Roberts    DATE Jan. 12-08.

12" SPEED LATHE
TAILSTOCK ASSEMBLY

SCALE 1/2 Size    DWG. NO. C-1036

# LESSON No. 41.

HEADSTOCK DETAILS.—Several of the details of a lathe headstock are shown on Drawing C–1037.

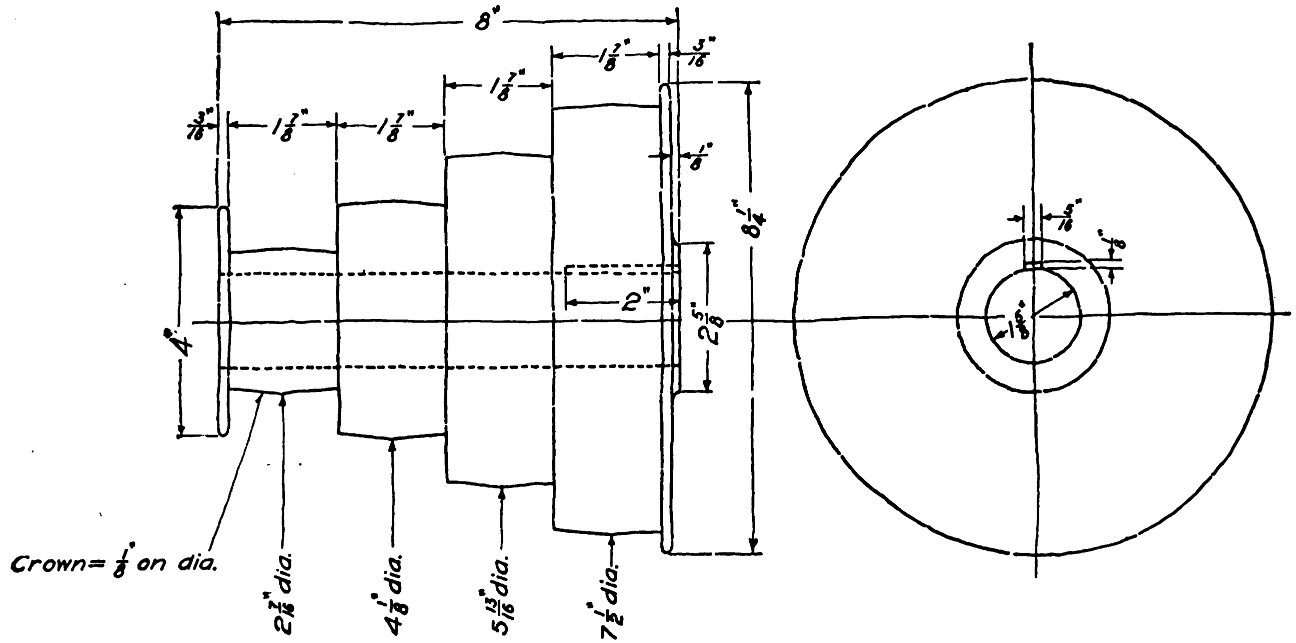
The cone pulley has four steps, or different diameters, giving four different speeds to the lathe spindle. Each step is made with its greatest diameter at the center; this is called "Crowning," and as a belt will naturally run on the greatest diameter, this is of value in keeping the belt on the pulley.

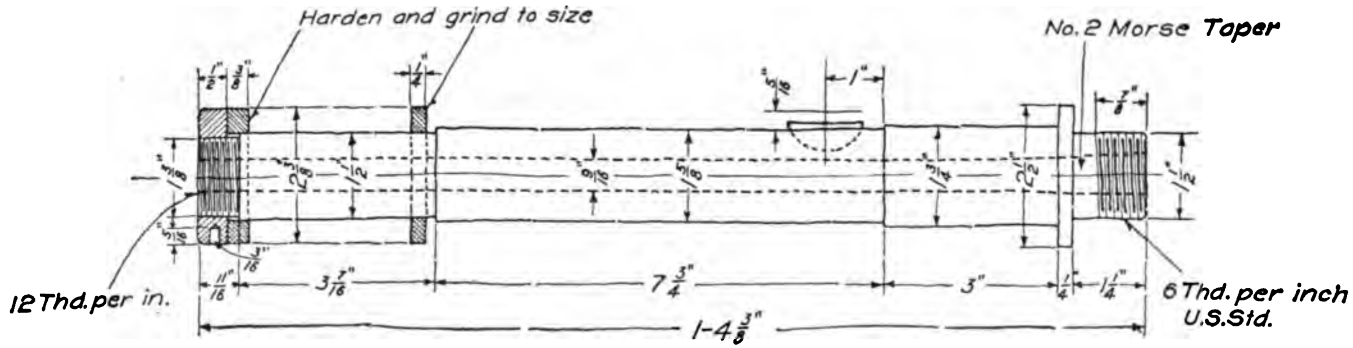
The diameters given are at the crown, which is of $\frac{1}{8}$ inch greater diameter than at the sides of each step.

The machine work on the spindle must be very carefully and accurately done; the journals and the inside of the nose end should be finished by grinding. The spindle is bored to allow for the center's easy removal, the "nose" end of the hole being tapered to suit the center shown on Drawing C–1035.

The spindle and the cone pulley are keyed together by means of a $1\frac{3}{8}$-inch Woodruff key.

The end motion of the spindle is taken up by means of the spanner nut, and the wear is taken by the hardened steel collar and washer shown on the small end of the spindle.




CLASS *Industrial*

NAME *John W. Roberts* DATE *Jan. 16-08.*

12" SPEED LATHE
HEADSTOCK DETAILS

SCALE 1/2 Size DWG. No. C.1037

# LESSON No. 42.

HEADSTOCK ASSEMBLY.—The assembly drawing of the lathe headstock illustrates the final detail of the speed lathe. From Drawing C–1038, make a half-size pencil drawing and tracing.

The headstock casting and the bearing caps are detailed on this drawing; thus it may be used both as a detail and as an assembly drawing.

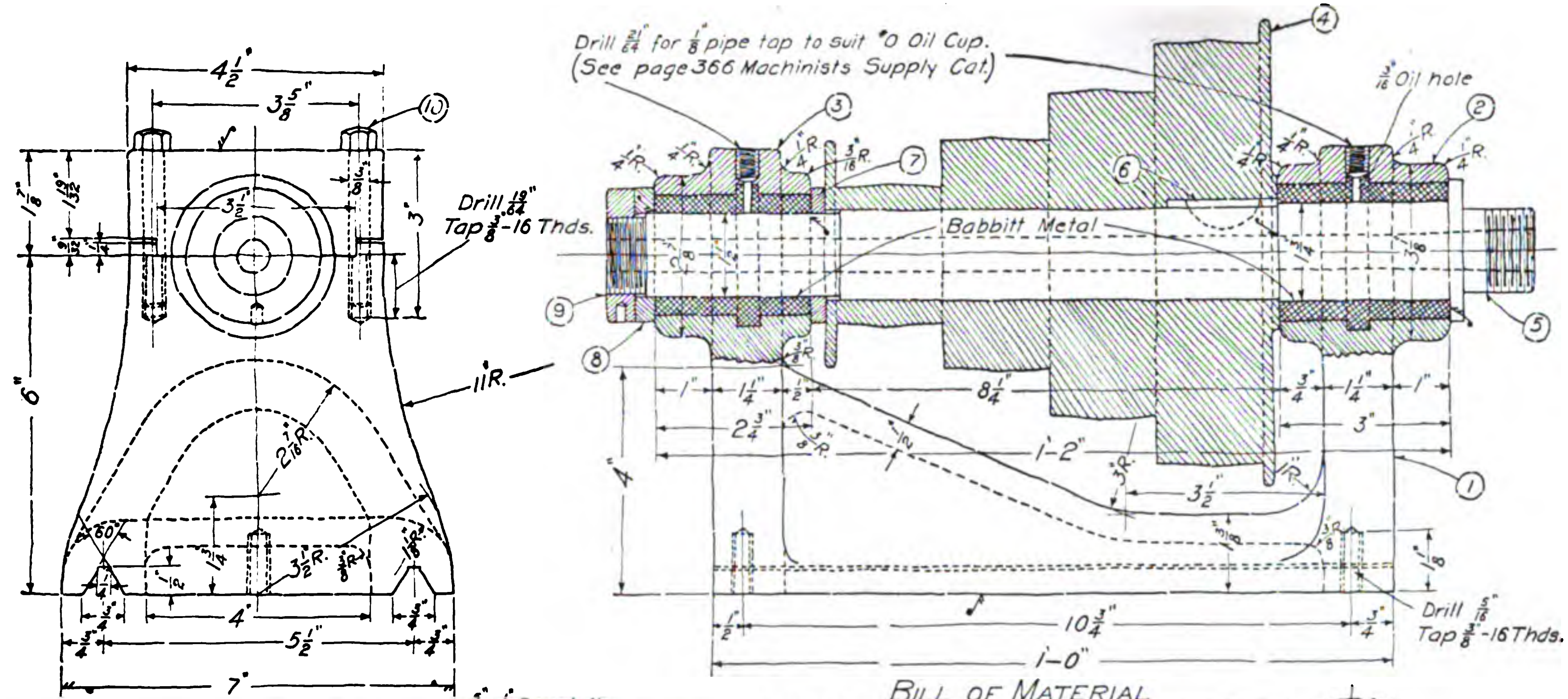
The bearings of Babbitt metal are cast solidly in the headstock and caps, being held in place by the collar and dovetails shown.

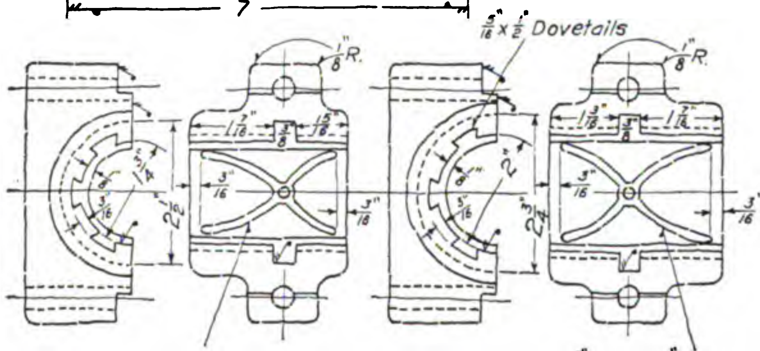
Oil cups are screwed into the caps, the oil being carried along the oil grooves the length of the bearings, thus keeping them well lubricated.

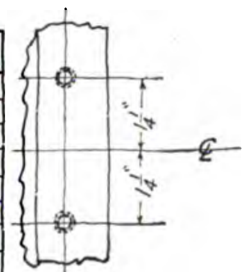
The headstock is fastened to the bed by means of cap screws, two being used at the front end and one at the rear end. Refer to the lathe-bed drawing to make sure that the positions of these screw holes coincide with those shown on the bed.

Lay out the "Bill of Material" carefully; make sure that no items are overlooked, as this must be complete to be of real value.

Try to get a clear understanding of all these lathe drawings and of the relations between the different parts; copy nothing blindly, but study each detail carefully, so that you may derive the benefit one is sure to obtain who thinks for himself.



Note: Oil Grooves in Headstock and Caps $\frac{1}{32}$" deep x $\frac{1}{4}$" wide
For Headstock details see Dwgs. C-1037 & C-1035

## Bill of Material

| Item No. | Description and Material | Pat. No. | Req. |
|---|---|---|---|
| 1 | Headstock, C.I. | 72 | 1 |
| 2 | Front Cap, C.I. | 73 | 1 |
| 3 | Rear Cap, C.I. | 74 | 1 |
| 4 | Cone, C.I. | 75 | 1 |
| 5 | Spindle, Corona Steel | | 1 |
| 6 | $\frac{5}{16}$x$1\frac{1}{8}$" Woodruff Key, C.R. | | 1 |
| 7 | Thrust Washer, Tool Steel | | 1 |
| 8 | Collar, Tool Steel | | 1 |
| 9 | Spanner Nut, C.R. | | 1 |
| 10 | $\frac{3}{8}$x$2\frac{1}{4}$" Hex. Hd. Cap Sc. | | 4 |
| 11 | $\frac{3}{8}$x$1\frac{1}{2}$" Hex. Hd. Cap Sc. | | 3 |
| 12 | Live Center, Tool Steel | | 1 |
| 13 | Oil Cup, Brass | | 2 |

CLASS Industrial

NAME John W. Roberts DATE Feb. 6-08.

12" Speed Lathe
Headstock Assembly

SCALE $\frac{1}{2}$ Size DWG. NO. C-1038

# LESSON No. 43.

SPECIFICATION.—The various details of a 12-inch speed lathe have been shown on the previous drawings; from these detail drawings the student is expected to get the necessary information to lay out a complete assembly drawing of the lathe.

This drawing should be placed on an "A"-size sheet (22"×30") and drawn to a scale of ½ size, showing two views—the front and the headstock end preferably.

Do not show any hidden parts, but draw to scale all parts that would be seen from the front and end of the machine.

The only dimensions that need be shown are the length and width at the feet, the center distances between the bolt holes in the feet in both views, and the distance (on the front view) from the inside edge of the flange of the small end of the cone pulley to the outside of feet at the headstock end.

These dimensions are of value for laying out the floor plan of a shop and in locating the countershaft in the proper position.

The main value to the student in such a drawing is that he will make an assembly drawing of something he has not seen, and he will obtain a better and clearer understanding of the relation between the various parts of the machine when he has put them together on paper.

Make a tracing of the finished pencil drawing, the title of which is 12-inch Speed Lathe Assembly, Drawing A-1039.

# LESSON No. 44.

STANDARD DATA.—In Lesson No. 15 reference was made to data sheets, or drawings, that are used to furnish standard information. In most modern drafting rooms, this reference information is placed on a standard-size sheet, so that these sheets may be kept in book form.

These data sheets are of great value to the draftsman for reference purposes, as they save time and labor; they are also of value in the production of drawings of uniform appearance.

The main object of the present lesson is to familiarize the student with this method of preparing reference matter in condensed form, so that it is readily available for use.

Information placed on these sheets must first of all be absolutely accurate. The sheet should be designed so that the desired information can be readily found, and the sheets should be of a uniform size, so that they may be bound together.

The dimensions given are for a sheet the size of which is convenient to illustrate a very wide class of subjects.

The subject-matter on the data sheet shown is U. S. standard screw threads, the sectional view indicating the shape and the proportions of this thread.

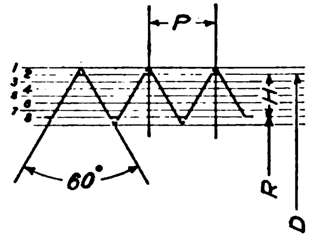
Make a pencil drawing and tracing of this lesson.

1'-0½"

For binding, trim print to this line

## U.S. STANDARD SCREW THREADS

| Bolt Diameter |  | Thds. per in. | Dia. at Root of Thread |  | Tap Drill, giving clearance of $\frac{1}{8}$ the height of thread triangle |  | Area at Root of Thd. | Safe Load of Bolt. Based on fibre stress of 6000 lbs. per sq. in. |
|---|---|---|---|---|---|---|---|---|
| Inches | Inches |  | Inches | Nearest 64th. | Inches | Nearest 64th. | Sq. in. | Pounds |
| $\frac{1}{4}$ | .250 | 20 | .185 | $\frac{3}{16}$ | .196 | $\frac{13}{64}$ | .027 | 162 |
| $\frac{5}{16}$ | .312 | 18 | .240 | $\frac{15}{64}$ | .252 | $\frac{1}{4}$ | .045 | 270 |
| $\frac{3}{8}$ | .375 | 16 | .294 | $\frac{19}{64}$ | .307 | $\frac{5}{16}$ | .068 | 408 |
| $\frac{7}{16}$ | .437 | 14 | .344 | $\frac{11}{32}$ | .360 | $\frac{23}{64}$ | .093 | 558 |
| $\frac{1}{2}$ | .500 | 13 | .400 | $\frac{13}{32}$ | .417 | $\frac{27}{64}$ | .126 | 756 |
| $\frac{9}{16}$ | .562 | 12 | .454 | $\frac{29}{64}$ | .472 | $\frac{15}{32}$ | .162 | 997 |
| $\frac{5}{8}$ | .625 | 11 | .507 | $\frac{1}{2}$ | .527 | $\frac{17}{32}$ | .202 | 1210 |
| $\frac{3}{4}$ | .750 | 10 | .620 | $\frac{5}{8}$ | .642 | $\frac{41}{64}$ | .302 | 1810 |
| $\frac{7}{8}$ | .875 | 9 | .731 | $\frac{47}{64}$ | .755 | $\frac{3}{4}$ | .420 | 2520 |
| 1 | 1.000 | 8 | .837 | $\frac{27}{32}$ | .865 | $\frac{55}{64}$ | .550 | 3300 |
| $1\frac{1}{8}$ | 1.125 | 7 | .940 | $\frac{15}{16}$ | .970 | $\frac{31}{32}$ | .694 | 4160 |
| $1\frac{1}{4}$ | 1.250 | 7 | 1.065 | $1\frac{1}{16}$ | 1.095 | $1\frac{3}{32}$ | .893 | 5350 |
| $1\frac{3}{8}$ | 1.375 | 6 | 1.160 | $1\frac{5}{32}$ | 1.215 | $1\frac{7}{32}$ | 1.057 | 6340 |
| $1\frac{1}{2}$ | 1.500 | 6 | 1.284 | $1\frac{9}{32}$ | 1.345 | $1\frac{11}{32}$ | 1.295 | 7770 |
| $1\frac{5}{8}$ | 1.625 | $5\frac{1}{2}$ | 1.389 | $1\frac{25}{64}$ | 1.428 | $1\frac{27}{64}$ | 1.515 | 9090 |
| $1\frac{3}{4}$ | 1.750 | 5 | 1.491 | $1\frac{31}{64}$ | 1.534 | $1\frac{17}{32}$ | 1.746 | 10470 |
| $1\frac{7}{8}$ | 1.875 | 5 | 1.616 | $1\frac{39}{64}$ | 1.659 | $1\frac{21}{32}$ | 2.051 | 12300 |
| 2 | 2.000 | $4\frac{1}{2}$ | 1.712 | $1\frac{23}{32}$ | 1.760 | $1\frac{49}{64}$ | 2.302 | 13800 |
| $2\frac{1}{4}$ | 2.250 | $4\frac{1}{2}$ | 1.962 | $1\frac{61}{64}$ | 2.010 | $2\frac{1}{64}$ | 3.023 | 18100 |
| $2\frac{1}{2}$ | 2.500 | 4 | 2.176 | $2\frac{11}{64}$ | 2.230 | $2\frac{15}{64}$ | 3.719 | 22300 |
| $2\frac{3}{4}$ | 2.750 | 4 | 2.426 | $2\frac{27}{64}$ | 2.480 | $2\frac{31}{64}$ | 4.620 | 27700 |
| 3 | 3.000 | $3\frac{1}{2}$ | 2.629 | $2\frac{5}{8}$ | 2.691 | $2\frac{11}{16}$ | 5.428 | 32500 |




$$\text{Pitch } P = \frac{1}{\text{Nbr. Thds per inch}}$$

$$\text{Depth of Thd. } H = P \times .6495$$

$$\text{Root dia. } R = D - \frac{1.299}{\text{Nbr. Thds. per in.}}$$

$$\text{Tap Drill} = D - \frac{1.0825}{\text{Nbr. Thds. per in.}}$$

THE CARNEGIE TECHNICAL SCHOOLS. Pittsburgh, Pa. SD-1040

STANDARD DATA

CLASS Industrial

NAME John W. Roberts DATE Dec. 7. 07.

SCALE DWG. NO. C-1040

# LESSON No. 45.

COMPOSITE DRAWING.—Any method of laying out work in the drafting room which reduces the general expense of producing drawings is to be commended. By using what are known as "composite drawings," we save making a large number of detail drawings.

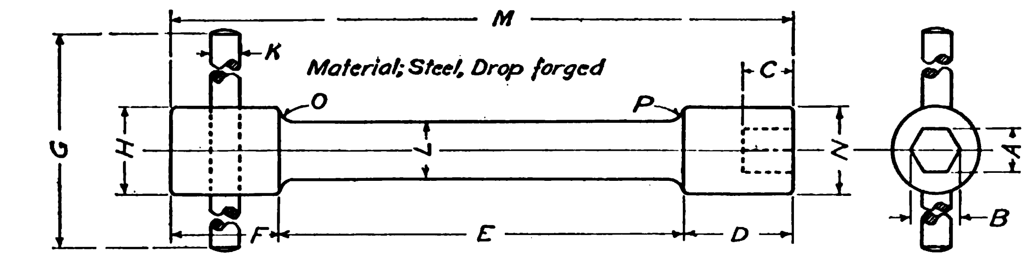
Firms that manufacture a standard line of machines usually design them in such a manner that the details of these machines are just alike except as to size. This being the case, a drawing can be made which represents all sizes of a particular detail. As it would be impossible to place the dimensions of all sizes on this one figure, letters are used to designate the various dimensions.

Below the drawing of the piece a table is laid out with these letters as headings, and under each letter are the dimensions, for that part represented by the letter, for each size of the piece illustrated.

As an illustration of the saving by this method, the present lesson is a composite drawing of a tap-bolt wrench; there are dimensions of twelve sizes shown; this one drawing then takes the place of twelve, and after one is familiar with the method, it is as readily and easily used as a separate detail drawing.

These drawings are of value for reference purposes, and can be prepared on the same size sheets as standard data, and can be used as such. They can be furnished to the shop men who machine the parts, and any notes as to material, finish, etc., can be placed upon a drawing of this kind, as well as upon any other drawing.

Make a pencil drawing and tracing of this lesson. Use care to make all of your figures clear and distinct, as there should never be any doubt as to a dimension.




| Bolt Diameter | A | B | C | D | E | F | G | H | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\frac{1}{4}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{7}{16}$ | $\frac{15}{16}$ | $3\frac{1}{2}$ | $\frac{15}{16}$ | 7 | $\frac{3}{4}$ | $\frac{1}{4}$ | $\frac{1}{2}$ | $5\frac{3}{8}$ | $\frac{3}{4}$ | $\frac{1}{8}$ | $\frac{1}{8}$ |
| $\frac{5}{16}$ | $\frac{15}{32}$ | $\frac{35}{64}$ | $\frac{1}{2}$ | 1 | $4\frac{1}{4}$ | 1 | 8 | $\frac{7}{8}$ | $\frac{3}{8}$ | $\frac{9}{16}$ | $6\frac{1}{4}$ | $\frac{7}{8}$ | $\frac{1}{8}$ | $\frac{1}{8}$ |
| $\frac{3}{8}$ | $\frac{9}{16}$ | $\frac{21}{32}$ | $\frac{9}{16}$ | $1\frac{1}{16}$ | $4\frac{1}{4}$ | $1\frac{1}{16}$ | 8 | $\frac{7}{8}$ | $\frac{3}{8}$ | $\frac{5}{8}$ | $6\frac{3}{8}$ | 1 | $\frac{1}{8}$ | $\frac{1}{8}$ |
| $\frac{1}{2}$ | $\frac{3}{4}$ | $\frac{27}{32}$ | $\frac{5}{8}$ | $1\frac{1}{8}$ | $4\frac{3}{4}$ | $1\frac{1}{8}$ | 9 | $1\frac{1}{8}$ | $\frac{3}{8}$ | $\frac{3}{4}$ | 7 | $1\frac{1}{4}$ | $\frac{3}{16}$ | $\frac{3}{16}$ |
| $\frac{5}{8}$ | $\frac{15}{16}$ | $1\frac{5}{64}$ | $\frac{3}{4}$ | $1\frac{1}{4}$ | $4\frac{3}{4}$ | $1\frac{1}{4}$ | 9 | $1\frac{3}{8}$ | $\frac{1}{2}$ | 1 | $7\frac{1}{4}$ | $1\frac{1}{2}$ | $\frac{3}{16}$ | $\frac{3}{16}$ |
| $\frac{3}{4}$ | $1\frac{1}{8}$ | $1\frac{19}{64}$ | $\frac{7}{8}$ | $1\frac{3}{8}$ | 5 | $1\frac{3}{8}$ | 10 | $1\frac{3}{4}$ | $\frac{1}{2}$ | $1\frac{1}{4}$ | $7\frac{3}{4}$ | $1\frac{3}{4}$ | $\frac{3}{16}$ | $\frac{3}{16}$ |
| $\frac{7}{8}$ | $1\frac{5}{16}$ | $1\frac{1}{2}$ | 1 | $1\frac{1}{2}$ | 5 | $1\frac{1}{2}$ | 10 | $1\frac{3}{4}$ | $\frac{1}{2}$ | $1\frac{3}{8}$ | 8 | 2 | $\frac{3}{16}$ | $\frac{1}{4}$ |
| 1 | $1\frac{1}{2}$ | $1\frac{47}{64}$ | $1\frac{1}{8}$ | $1\frac{5}{8}$ | $5\frac{1}{4}$ | $1\frac{1}{2}$ | 11 | 2 | $\frac{1}{2}$ | $1\frac{1}{2}$ | $8\frac{3}{8}$ | $2\frac{3}{8}$ | $\frac{1}{4}$ | $\frac{3}{8}$ |
| $1\frac{1}{4}$ | $1\frac{7}{8}$ | $2\frac{5}{32}$ | $1\frac{3}{8}$ | $1\frac{3}{4}$ | $5\frac{1}{4}$ | $1\frac{1}{2}$ | 11 | $2\frac{1}{4}$ | $\frac{1}{2}$ | $1\frac{3}{4}$ | $8\frac{1}{2}$ | $2\frac{3}{4}$ | $\frac{1}{4}$ | $\frac{3}{8}$ |
| $1\frac{1}{2}$ | $2\frac{1}{4}$ | $2\frac{19}{32}$ | $1\frac{5}{8}$ | $1\frac{7}{8}$ | $5\frac{1}{2}$ | $1\frac{1}{2}$ | 12 | $2\frac{1}{2}$ | $\frac{1}{2}$ | 2 | $8\frac{7}{8}$ | $3\frac{3}{8}$ | $\frac{1}{4}$ | $\frac{1}{2}$ |
| $1\frac{3}{4}$ | $2\frac{5}{8}$ | $3\frac{1}{32}$ | $1\frac{7}{8}$ | 2 | $5\frac{1}{2}$ | 2 | 13 | $2\frac{3}{4}$ | $\frac{9}{16}$ | $2\frac{1}{4}$ | $9\frac{1}{2}$ | $3\frac{7}{8}$ | $\frac{1}{4}$ | $\frac{1}{2}$ |
| 2 | 3 | $3\frac{15}{32}$ | $2\frac{1}{4}$ | $2\frac{3}{8}$ | $5\frac{1}{2}$ | $2\frac{1}{4}$ | 14 | $3\frac{1}{4}$ | $\frac{9}{16}$ | $2\frac{3}{4}$ | $10\frac{1}{8}$ | $4\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{1}{2}$ |

THE CARNEGIE TECHNICAL SCHOOLS, Pittsburgh, Pa. CD.1041

COMPOSITE DRAWING

CLASS Industrial

NAME John W. Roberts DATE Dec. 8_07

SCALE

DWG. No. C_1041

# LESSON No. 46.

BENCH GRINDER DETAILS.—Part of the details of a Bench Grinder are shown on Drawing C–1042. These details are shown in the same manner as they would be on a regular working drawing. The main object of this and of the following lessons pertaining to this machine is to give the student additional practice in making working drawings, so that he may acquire the mechanical skill necessary to the able draftsman.

The steel spindle shown has two grooves turned in each of the journals; these grooves are not entirely filled with the Babbitt metal of the bearings, and this space, being filled with oil, is of considerable value in keeping the journal well lubricated.

One end of the spindle is threaded for a right-hand nut and the other end for a left-hand nut. This decreases the possibility of the nuts unscrewing and allowing the emery wheel to fly off.

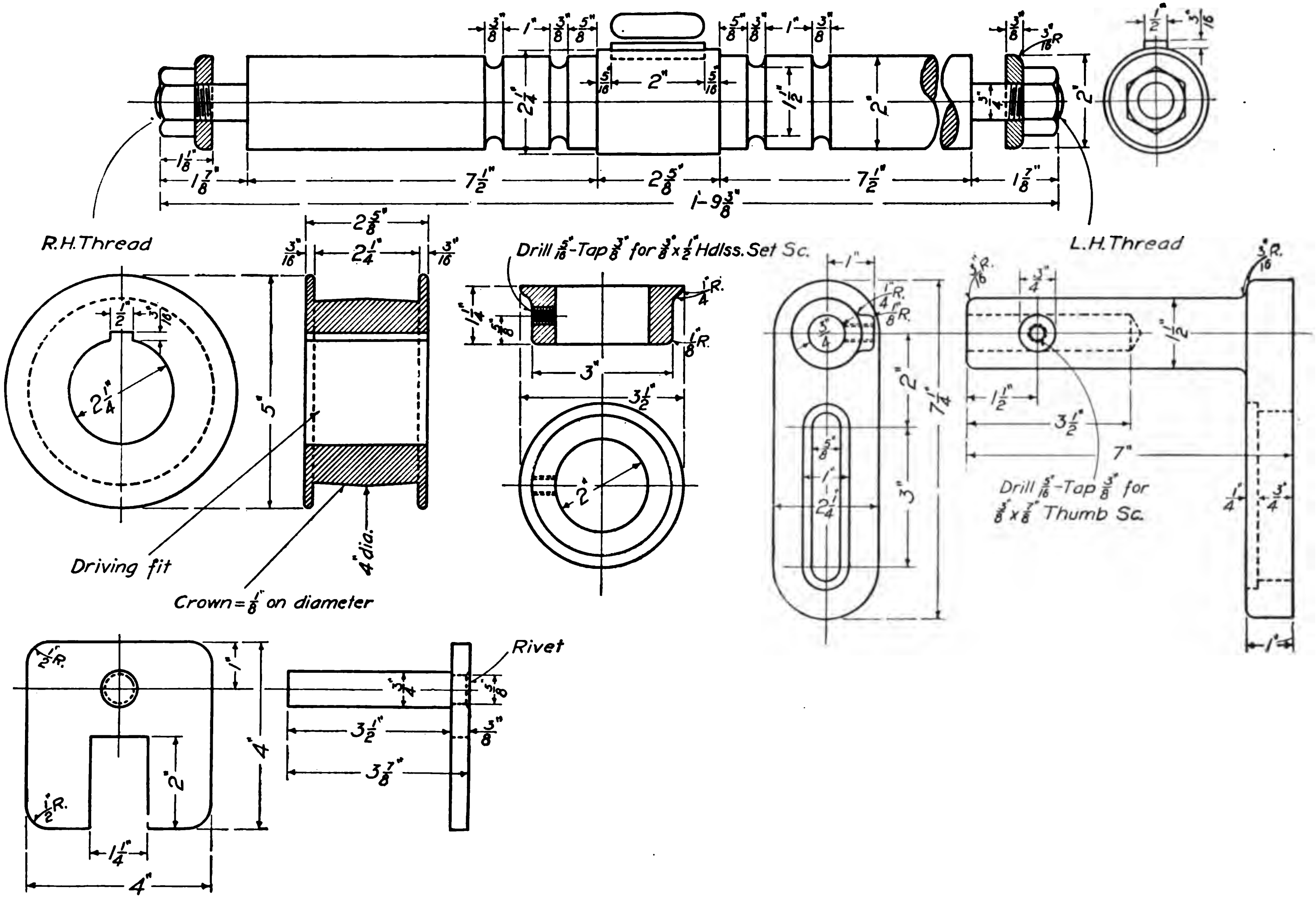
The pulley should be a "driving fit" on the spindle to obtain the best wearing results.

Two collars are required—one on the outside of each bearing. These collars help to keep emery dust out of the bearings and also prevent "end play" of the spindle.

The "work rest" is a wrought-iron plate riveted to a cold rolled-steel stem. This "work rest" can be raised or lowered, and is held at the proper height by a thumb screw in the "rest stand" which supports it.

The material of the rest stands, the collars, and the pulley is cast iron.

Make an accurate pencil drawing and tracing of this lesson. Do the best work of which you are capable on all of these drawings.




CLASS *Industrial*

NAME *John W. Roberts* DATE *Dec. 10-07.*

## BENCH GRINDER DETAILS

SCALE 1/2 Size DWG. No. C.1042

# LESSON No. 47.

BENCH GRINDER DETAILS.—The rest of the details of a Bench Grinder are shown on Drawing C–1043.

The cast-iron frame has split bearings, the illustration showing the wearing surface of Babbitt metal cast solidly in the frame and caps. The Babbitt metal is held in place by circular anchors cored in the caps and frame.

A felt washer is set into the sides of each bearing for the purpose of keeping emery dust out of the bearings.

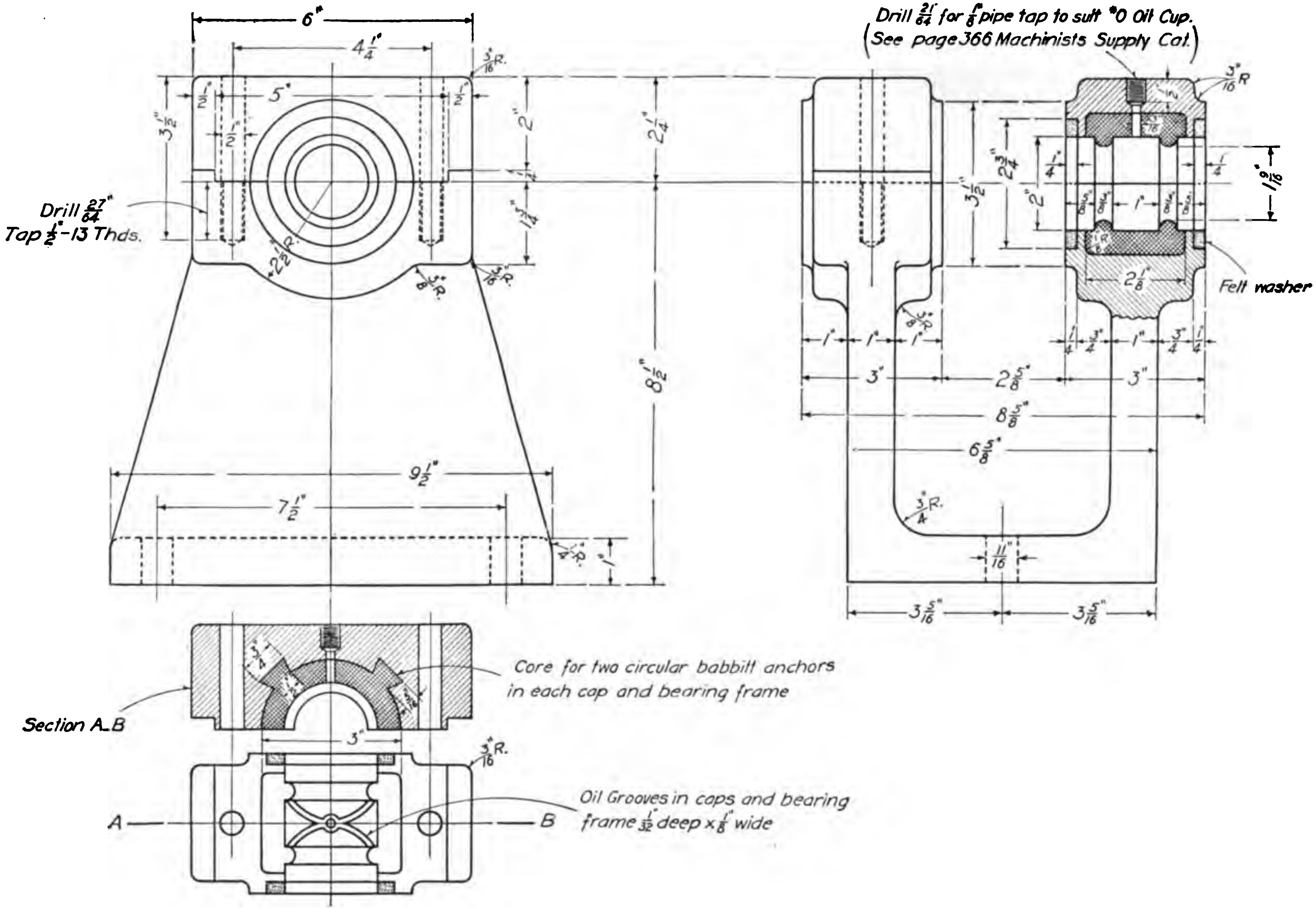
The circular ribs of Babbitt metal fit into the grooves of the spindle shown on Drawing C–1042. These ribs do not entirely fill the grooves, thus allowing a film of oil to be carried, which helps materially in keeping the journal well lubricated.

The oil supply for the bearing is furnished by an oil cup which is screwed into the top of the cap.

Where the caps are fitted into the frame, no "draw" is allowed; this is an additional precaution to keep emery dust away from the bearings.

Do your work well. Do not be satisfied with what you consider "good enough"; nothing but the very best that you can do is likely to be acceptable to the chief draftsman.

The design for this grinder was taken from the "American Machinist."




BENCH GRINDER FRAME

CLASS Industrial

NAME John W. Roberts DATE Dec. 16-07.

SCALE $\frac{1}{2}$ Size DWG No. C-1043

# LESSON No. 48.

ASSEMBLY SPECIFICATION.—On Drawings C–1042 and C–1043 are shown the details of a Bench Grinder; from these details and the following information the student is expected to lay out a complete half-size assembly drawing of the Grinder. This drawing should be laid out upon a "B"-size sheet, showing the front and the end views.

The two emery wheels used are 8 inches in diameter by $\frac{3}{4}$ inch thick, and have a $\frac{3}{4}$-inch bore. These wheels should be shown in place on the spindle, with an arrow indicating the direction in which they revolve.

The student must indicate which end of the spindle has a right-hand nut, and which end the left hand, thus showing whether he has clearly understood the reason for this practice.

The whole assembly should be mounted upon a cast-iron plate 1′-8″×1′-10″×$\frac{3}{4}$″ thick. Use $\frac{5}{8}$-inch hexagon-head through bolts to fasten the bearing frame to the plate.

Place the work-rest stands in front of the frame in the proper position to suit the wheel in each case. Use $\frac{1}{2}$-inch square-head bolts with thumb nuts to clamp the stands to the plate.

The student is expected to decide for himself the length of the bolts mentioned above, also the length of the cap screws for fastening the bearing caps to the frame. He must lay out a "Bill of Material" which will contain each item used in the construction of the grinder.

No dimensions need be shown upon this assembly drawing, but it must be drawn accurately to scale. Make a tracing of the finished pencil drawing.

The title of this drawing is "Bench Grinder Assembly," Drawing B–1044.

# LESSON No. 49.

COMMUTATOR BAR.—The illustration shown on Drawing C–1045 represents a Commutator Bar or a single segment of the commutator of an electric generator.

The bar is cut from copper plate that has been rolled to the correct taper and thickness; the copper must be of the best quality and as hard as it is possible to make it, to insure good wearing qualities.

These bars are cut to the dimensions shown by the solid outline; they are then built up into a ring with strips of mica insulation between the bars. This ring of bars is held by circular clamps while the inside of the commutator is bored out to the sizes indicated by the dotted lines on the lower half of the bar.

The necks are brazed into a slot milled in the top of the bar. These necks form a connection between the armature coils and the bars.

The face of the bar is the part that helps to form the surface of the commutator which comes in contact with the carbons or brushes.

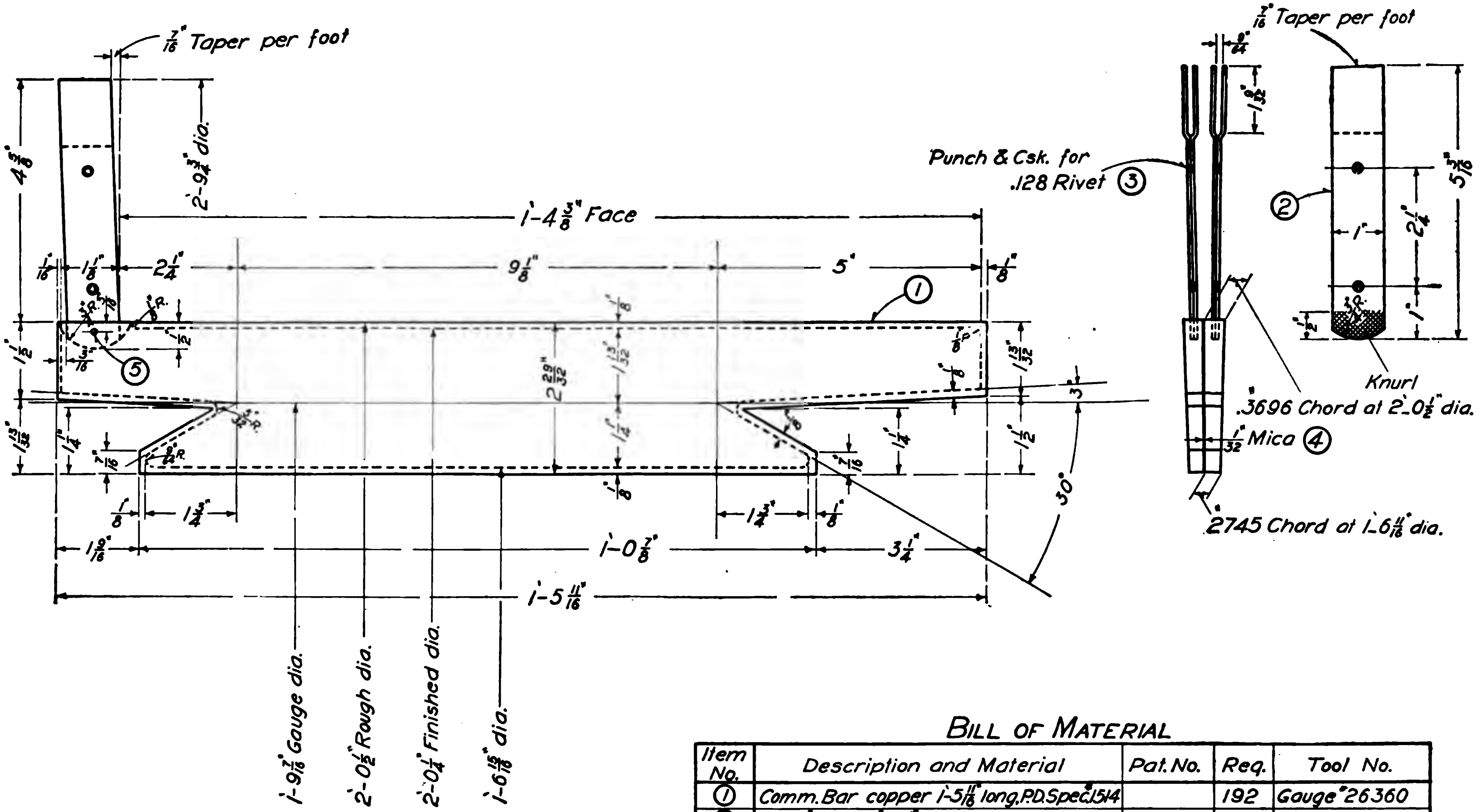
The mica insulation shown is one of the best-known non-conductors of electricity. Thin pieces of mica pasted together with shellac form the sheets from which these strips are cut or punched by means of dies.

The term "P. D. Spec." refers to the "Purchasing Department Specification," under which many large firms purchase their supplies.

The expression "Gauge Diameter" is one method used to denote the size of the commutator; it is of value mainly to the engineer and draftsman, as it is an imaginary diameter used as a basis when laying out the various parts of a commutator.

Use a protractor when laying out the angular surfaces of the bar.

Make this drawing carefully and accurately.




## Bill of Material

| Item No. | Description and Material | Pat. No. | Req. | Tool No. |
|---|---|---|---|---|
| ① | Comm. Bar copper 1'-5 11/16" long, P.D. Spec. #1514 | | 192 | Gauge #26360 |
| ② | Neck, .0641 X 1 X 5 1/4" Grade B copper strap | | | |
| | P.D. Specification #1431 | | 384 | |
| ③ | Rivets, S #24358 | | 384 | |
| ④ | Mica, 1/32" X 2 15/16" X 1'-5 11/16" | | 192 | Die #22918 |
| ⑤ | Rivet, .128 X 3/8" copper wire | | 192 | |

# Commutator Bar

CLASS Industrial

NAME John W. Roberts DATE Jan. 12-09.

SCALE 1/2 Size DWG. No. C-1045

# LESSON No. 50.

FRONT COMMUTATOR RING.—We mentioned in our last lesson that the commutator bars were held by circular clamps while being bored out. After the boring is finished, the commutator may be slipped onto the "spider," where it is held in place by V-shaped rings.

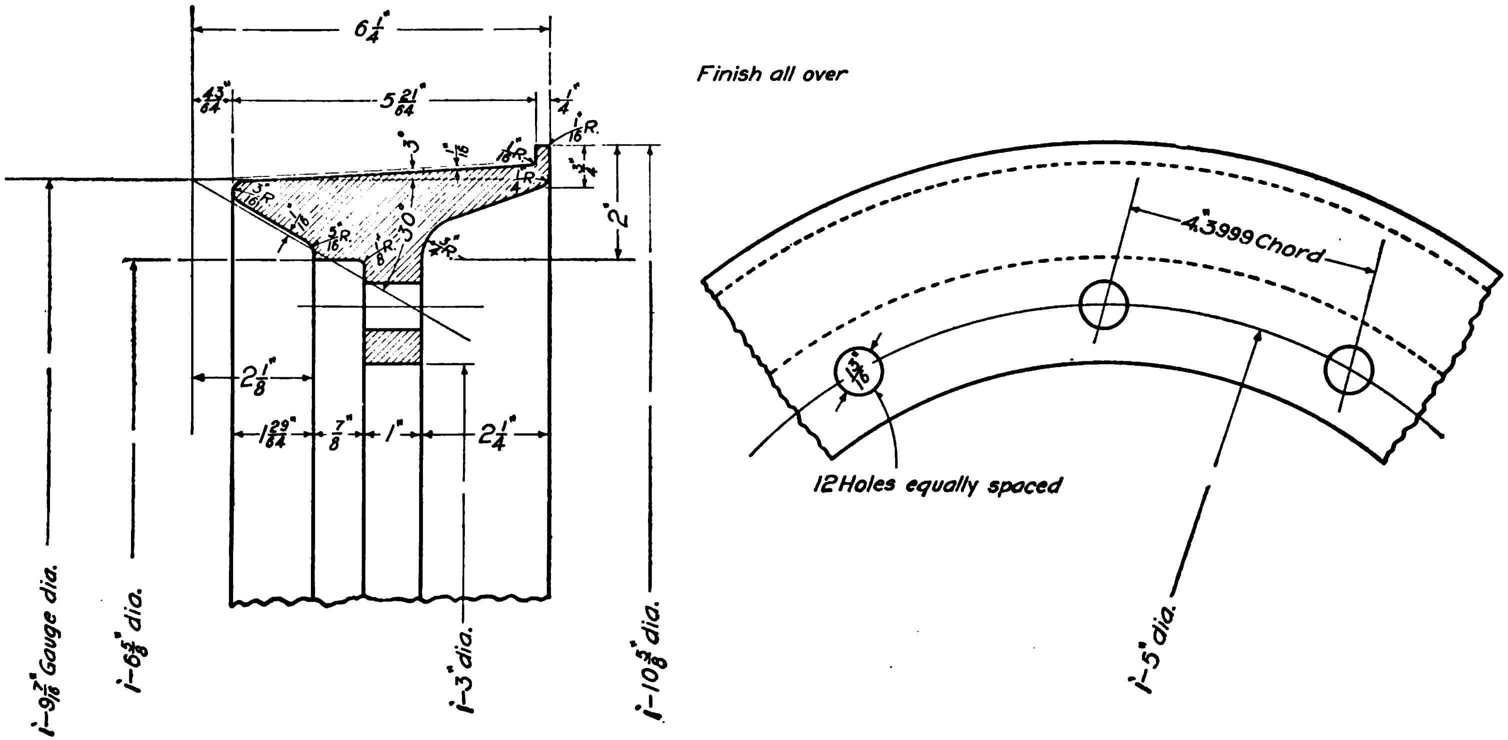
On Drawing C–1046 is shown the front or outside ring. This ring is held in place by twelve $\frac{3}{4}$-inch studs screwed into the end of the armature spider.

When laying out this ring drawing, use the "gauge line" as the starting-point, as this with the angular lines ($3°$ and $30°$) fix the position of the ring.

The front ring is made of cast steel (c. s.) and should be machined all over.

The narrow lip or flange on the outer edge of the ring is for the purpose of throwing off any oil that may leak out from the main-shaft bearings. If oil should work over the edge of the ring and get into the commutator, it is quite likely to "short circuit" and burn out the machine.

These drawings are quite simple, but they must be drawn with care as to neatness and accuracy.




**FRONT COMMUTATOR RING**

CLASS *Industrial*

NAME John W. Roberts DATE Jan. 16-09.

SCALE $\frac{1}{2}$ Size DWG. No. C-1046

# LESSON No. 51.

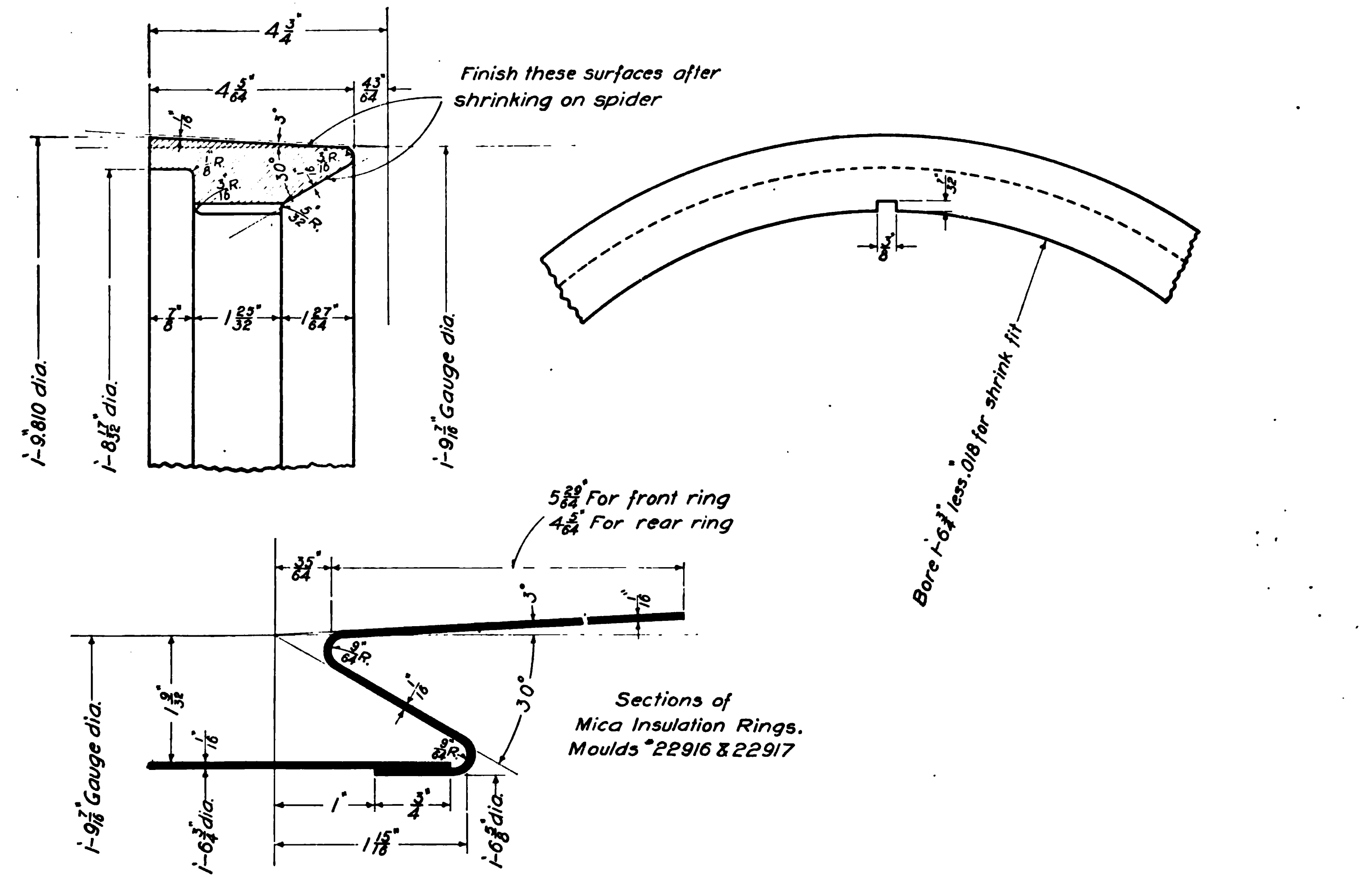
REAR COMMUTATOR RING. — On Drawing C-1047 is shown a Rear Commutator Ring. This cast-steel ring is to be shrunk onto a cast-iron armature spider and, in connection with the ring described in our previous lesson, holds the commutator bars tightly together in the form of a cylinder, the outer surface of which comes in contact with the carbons.

For machines of low speed, these end rings are usually made of cast iron, the rear ring being a part of the armature spider, but it is much safer to use wrought iron or steel for machines of high speed, as the stresses are quite high through the nose of the ring.

In addition to shrinking on, this ring is located in place by a $\frac{3}{8}'' \times \frac{3}{8}'' \times 1\frac{1}{2}''$ key, shown on Drawing C-1048.

A sectional view of the mica insulation rings is shown on our present lesson. One of these rings is placed at each end of the commutator bar, between the bar and the end rings, while the flat ring fits into the flanges of the end insulation rings, as shown, and over the body of the armature spider, insulating that from the commutator.

As mentioned in the previous lesson, the student should make use of the "gauge line" as a starting-point when laying out this lesson.




REAR COMMUTATOR RING

CLASS Industrial

NAME John W.Roberts DATE Jan. 20_09.

SCALE ½ & Full Size DWG. No. C.1047

# LESSON No. 52.

ARMATURE SPIDER.—The illustration on Drawing C-1048 shows three views of an Armature Spider with the rear commutator ring keyed in place. The surface of this rear ring which forms the dovetail is finished after being shrunk on the spider.

Some special sections are shown for the purpose of bringing out clearly the shape of the spider; in addition only half of the spider is shown, as this is sufficient and much time and labor are saved thereby.

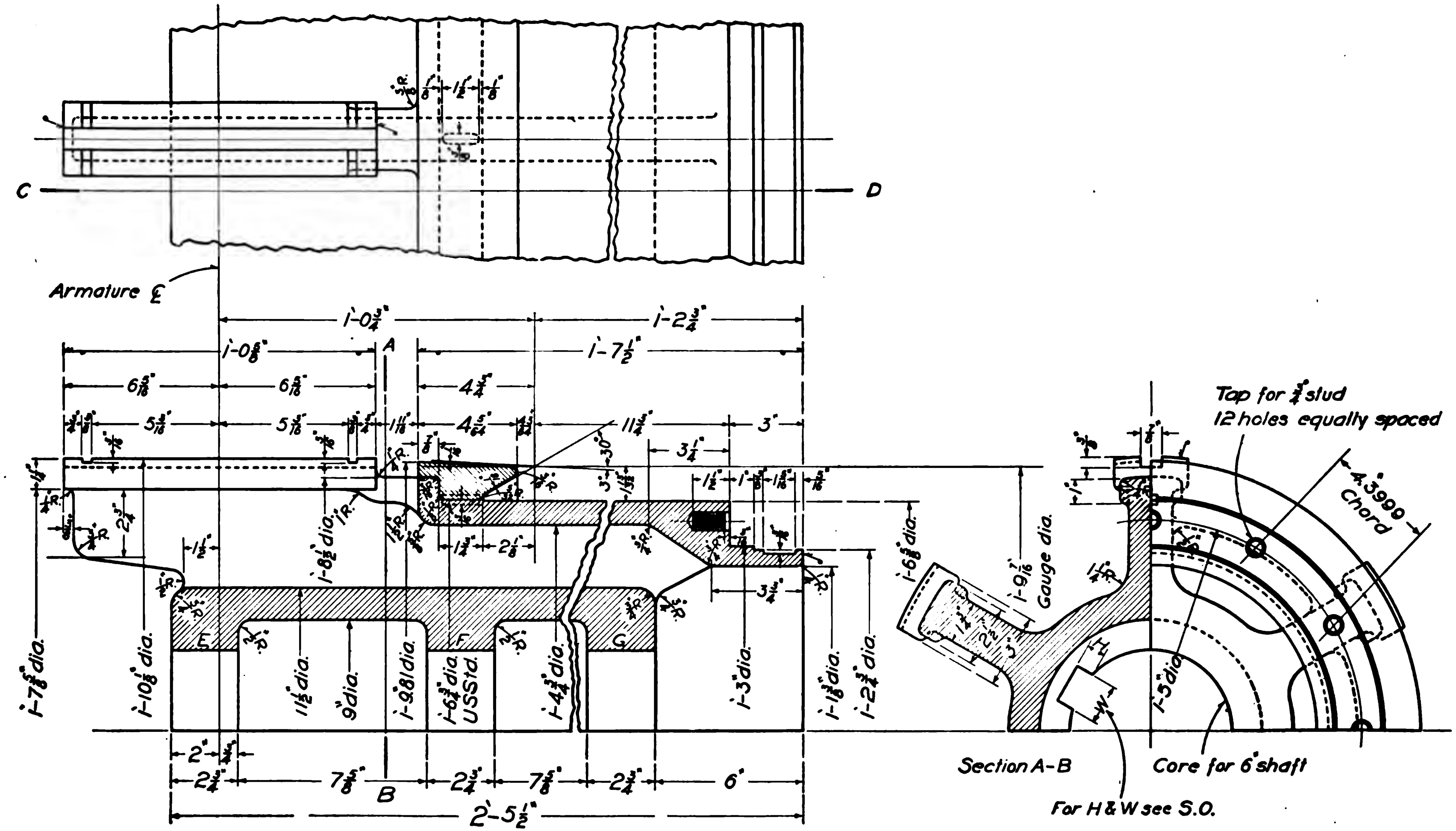
When building engine-type generators, it is often customary for one firm to build the engine and another firm to build the generator. The builders of the engine usually furnish the shaft, the sizes of which are indicated in the "stock order" furnished the generator builders.

For the convenience of the student, he may show bores E, F, and G to scale for a diameter of 6 inches, and the keyway may be shown with W equal to 1½ inches and H equal to ½ inch.

The dovetail surface of the spider is turned to suit a "gauge" or templet made to suit this particular size and type of machine.

When laying out this drawing, study for yourself the relation between the spider and the parts detailed on the previous lessons, as this information will be of value in the following lesson.

Lay this lesson out half-size on an A sheet (22″×30″), as it is a poor plan to make a drawing to a small scale when it means a sacrifice of clearness to do so.




Section C-D

For bores E, F & G see Stock Order

## ARMATURE SPIDER

CLASS Industrial

NAME John W. Roberts DATE Jan. 26-09.

SCALE ¼ Size DWG. NO. C.1048

# LESSON No. 53.

COMMUTATOR ASSEMBLY.—On Drawings C–1045, C–1046, C–1047, and C–1048 are shown the main details of the commutator for an electric generator. From these drawings and the following information it is expected that the student will lay out an assembly drawing of the commutator.

On this assembly drawing it is nesessary to show but one view—a lengthwise sectional view similar to Section C–D on Drawing C–1048.

The main purpose of these later assembly drawings given in this course of lessons, aside from the general knowledge of the subject necessary in the drafting room, is to teach the student to *think for himself*. To lay out something which he cannot see requires him to think of and to clearly understand his problem before he can do the work. In other words, if the student is a mere copyist, he cannot do his work intelligently.

Show one of the studs for holding the front ring in place with a $\frac{1}{2}$-inch plain washer and a $\frac{1}{2}$-inch lock washer under the nut.

Between the front ring and the nose of the spider which it fits over is an opening $\frac{3}{8}$ inch wide and $\frac{1}{8}$ inch deep; this opening is filled with oakum packing to prevent dust and oil from working into the commutator from below.

Where the mica insulation rings project beyond the ends of the commutator bar, they are wrapped with $\frac{3}{32}$-inch torpedo twine, and over that is wound a layer of surgical tape.

Lay out this drawing to a half-size scale on a B-size sheet.

It may be necessary for you to do some *thinking* before you can lay out this lesson, but *that* is what we expect you to do.

When preparing the "Bill of Material," be careful to include each item required for a complete commutator.

The title of this drawing to be "Commutator Assembly," Drawing B–1049.

# LESSON No. 54.

GENERATOR FRAME.—The main object of the lesson shown on Drawing C–1050 is to give the student additional practice, so that he may acquire the mechanical skill necessary to become a first-class draftsman.

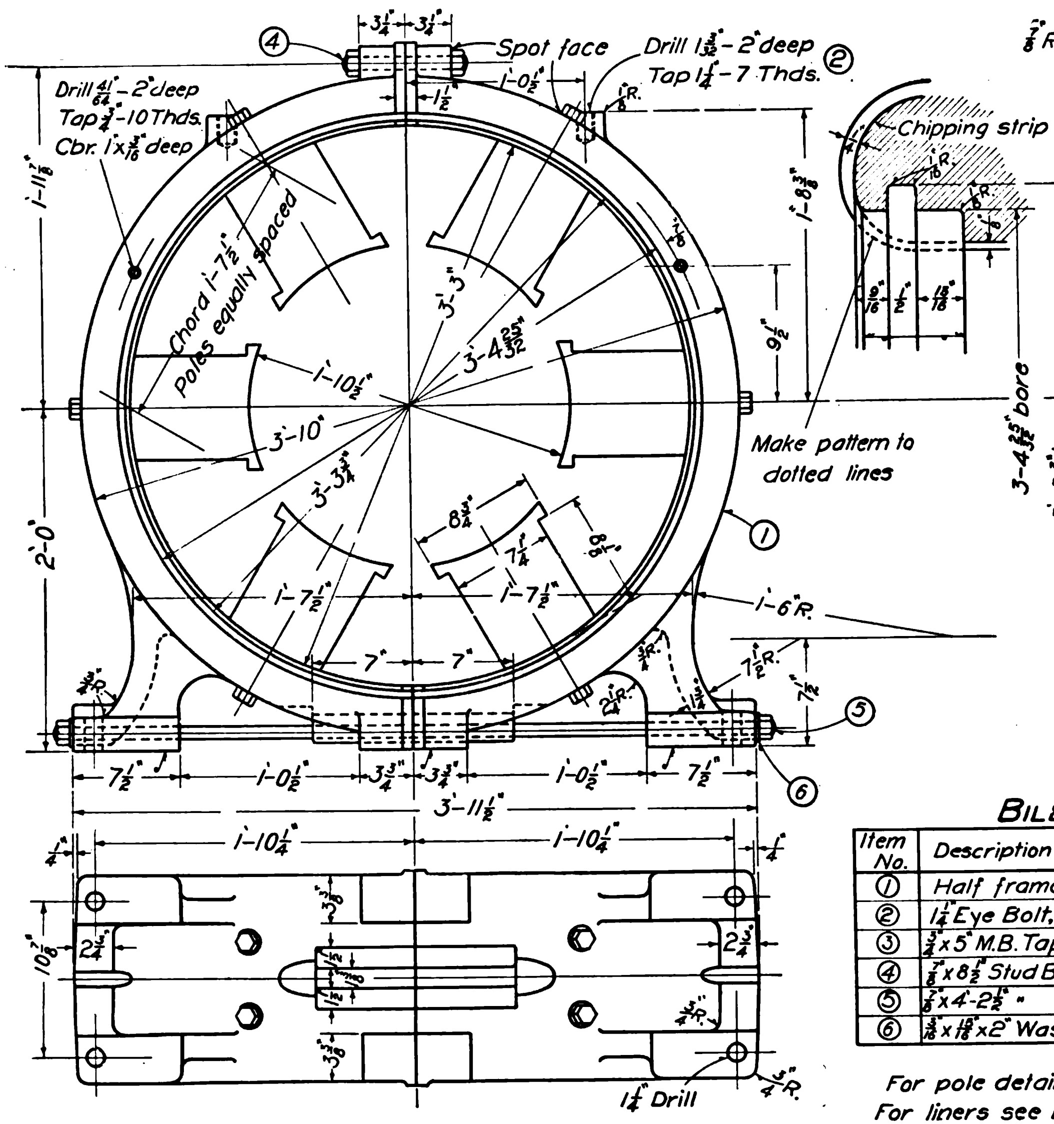
There is no relation between the generator frame drawing and the previous generator drawings, as this frame belongs to a machine of different size.

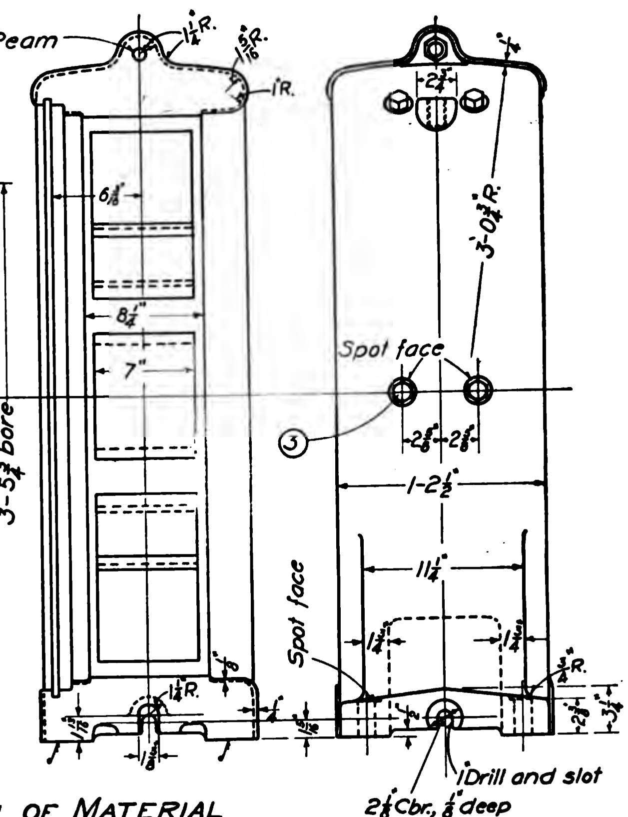
Where large castings are fitted together and the edges of the surfaces which join are left rough, it is quite common practice to cast on what is known as a "chipping strip," or a narrow strip of metal that may be chipped and filed until the two edges of the castings match. These narrow strips of metal are more quickly and easily matched than wider surfaces would be.

The "chipping strip" shown on the halves of the generator frame illustrates the value of the above-mentioned practice.

Lay out this lesson on an A-size sheet, using a scale of one-quarter size.

Do the best work you are capable of, as nothing but the very best you can do will be satisfactory.




## Bill of Material

| Item No. | Description and Material | Pat. No. | Req. |
|---|---|---|---|
| 1 | Half frame, C.I. | M.7064 | 2 |
| 2 | $1\frac{1}{4}$" Eye Bolt, W.I. | | 2 |
| 3 | $\frac{3}{4}$" x 5" M.B. Tap Bolt, W.I. | | 12 |
| 4 | $\frac{7}{8}$" x $8\frac{1}{2}$" Stud Bolt with S.F. Nuts | | 1 |
| 5 | $\frac{7}{8}$" x $4'-2\frac{1}{2}$" " " " " | | 1 |
| 6 | $\frac{15}{16}$" x $1\frac{13}{16}$" x 2" Washer, W.I. | | 2 |

For pole details see Dwg. B-104049
For liners see Dwg. C-118049

GENERATOR FRAME

CLASS Industrial

NAME John W. Roberts DATE Feb. 6-09.

SCALE $\frac{1}{8}$ Size DWG. NO. C-1050

# LESSON No. 55.

WORM GEARING.—The subject of the present lesson, Worm Gearing, is one with which shop men are not so familiar as they are with spur and bevel gearing, both of which are in more common use than the former for transmission purposes.

For various purposes worm gearing is more desirable than bevel gearing, especially so where great speed reduction is necessary.

The worm which drives the gear is simply a section of a screw, the thread of which is especially suitable for the purpose of engaging with the gear teeth. This screw thread is made with a flat-top, the sides being inclined at an angle of 14° 30′, or an included angle between the sides of 29°, and is known as the Acme thread.

To obtain the best results it is necessary to cut the teeth in the gear, by means of a "hob" or tap, slightly larger than the worm. The process of "hobbing a gear" consists of holding the hob and the gear in a suitable manner and revolving the hob against the edge or face of the gear until the teeth are cut to the correct depth.

The ratio between the revolutions of the worm and the revolutions of the worm gear are as follows:

| | | |
|---|---|---|
| Single | thread worm = | number of teeth in gear to 1. |
| Double | " " = | " " " " " " 2. |
| Triple | " " = | " " " " " " 3. |
| Quadruple | " " = | " " " " " " 4. |

By the term "pitch" of worm is meant the linear distance a nut travels for each revolution of the screw.

The increased speed of the gear driven by a double-thread worm (compared to a single-thread worm) is not due to the worm being double threaded, but is due to the increased pitch of the worm, which makes a double thread a mechanical necessity, as in double-thread screws a single thread of the same pitch would weaken the worm too much, often nearly cutting it in two. The double-threaded worm presents more tooth surface in contact at the same time, thus adding materially to the strength and wearing qualities of the worm.

To get good results with high-speed worm gearing, the worm should be made with the outside diameter about equal to the pitch; this gives a tangent thread angle of 17° 15′. Several authorities prefer a worm with even greater pitch, so as to give a thread angle of 20°.

The circular pitch of the worm gear is equal to the linear distance from the center of one tooth to the center of the next tooth of the worm.

USEFUL WORM-GEAR FORMULAS.

Circular pitch or C. P. $= \dfrac{\pi}{\text{D. P.}}$ $(\pi = 3.1416)$.

Diametral pitch or D. P. $= \dfrac{\pi}{\text{C. P.}}$.

Pitch diameter $= \dfrac{\text{Number of teeth} \times \text{C. P.}}{\pi}$

Throat diameter = pitch diameter $+ \dfrac{2}{\text{D. P.}}$

Blank diameter = pitch diameter $+ \dfrac{4}{\text{D. P.}}$

Teeth of gear are of the same proportions as a section of the worm thread.

Addendum or height of tooth from pitch lines to throat $= \dfrac{1}{\text{D. P.}}$.

Dedendum or tooth below pitch line = addendum + clearance.

Clearance = one-eighth of addendum height.

Whole depth of tooth = addendum + dedendum or C. P. $\times .6763$

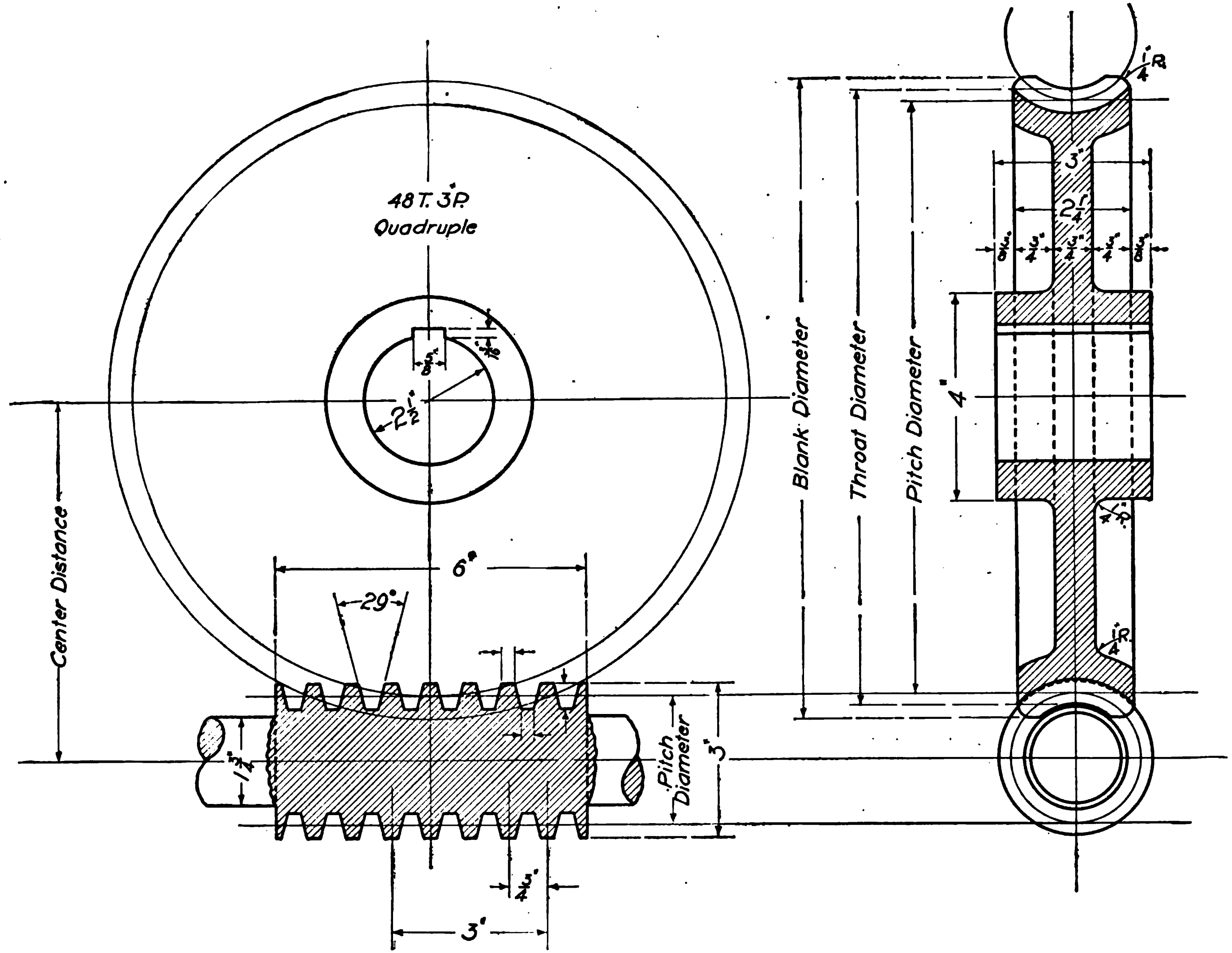
Width of worm thread at top = C. P. $\times .3354$.

Width of thread tool at end = C. P. $\times .3148$.

The face of the worm gear is usually made equal to from one-half to three-fourths of the outside diameter of the worm.

LESSON.—On Drawing C–1051 is shown a worm gear of 48 teeth, 3-inch pitch quadruple, engaged with a worm of 3-inch pitch quadruple thread. From the formulas given above the student is expected to obtain all the dimensions necessary to lay out this gear and worm. Put in the correct dimensions where they are shown blank on this drawing.

Make your tracing neatly and carefully.




WORM GEARING

CLASS Industrial

NAME John W Roberts    DATE Jan. 6-09.

SCALE ½ Size    DWG. No. C-1051

# LESSON No. 56.

**PLATE CAM.**—The subject of cams is such a large one that we can touch upon it but briefly in this course of lessons.

Cams may be divided into two classes: "positive" and "non-positive." Each of these classes may be again subdivided into many types of cams.

A positive cam is one where the impulse transmitted by it is definite and continuous, as the motion transmitted by gear wheels. A non-positive cam lifts a roller or slide by the friction of its surface, but the roller or slide falls back to rest of its own weight, or is pulled back by a spring.

Our present lesson is an illustration of a non-positive cam. This is one of the many cams the body of which is an irregularly shaped plate mounted upon a shaft; the edge of the plate, revolving against a roller or slide, lifts or pushes it in a plane at right angles to the shaft.

The problem is to lay out a cam that will raise the lever roller from rest on the base circle 1½ inches during one-sixth of a revolution or 60°, the lever to remain stationary for 60° of the revolution, to fall ¾ inch in 30°, to remain stationary for 45°, to fall the remaining ¾ inch to rest in 30°, and to remain at rest for the balance of the revolution.

In practice the size of the shaft and the hub diameter of the cam fix the minimum diameter of the base circle, for this should be at least ¼ to ½ inch larger in diameter than the hub.

When the size of the base circle has been decided, lay out the motion diagram or chart, which is a graphical picture of the path of the cam roller. The length of the base line of the chart is equal to the circumference of the base circle. Each of the spaces between the vertical lines represents 15° on the present chart, but the base line may be divided into any number of equal divisions that will suit the degrees of circumference occupied by the various movements.

This chart should be laid out to scale as to length, proportionate divisions of length, and the height or throw. Full size is preferable where possible.

To get the best results as to wear, the edge of the cam or the curved path of the roller should be so designed as to create the least friction possible. What is known as the harmonic curve is used largely by designers of cams. This curve is illustrated on our present lesson and is laid out in the following manner:

Throw in a semicircle equal to the "throw" of the cam; divide this half circle into an equal number of parts—the same number into which the angle of the movement is divided. Project these division points upon the base line of the semicircle, then with the compass pivoted at the shaft center, swing in circular projection lines from these base-line points until they intersect the radial division lines. The points of intersection are the points forming the desired curve, or if allowance was made for the radius of the roller, as in our present lesson, these points are the center of the roller in the different positions it would take in moving around the cam.

In actual practice the cam revolves against the roller, but for the convenience of the draftsman, the work is laid out as if the roller were moved around the cam.

For the benefit of those students who have not understood the meaning of the term "throw" in this lesson, it should be explained that this refers to the distance the roller moves away or toward the shaft center as the cam revolves.

Make a full-size pencil drawing and tracing of the plate cam illustrated.

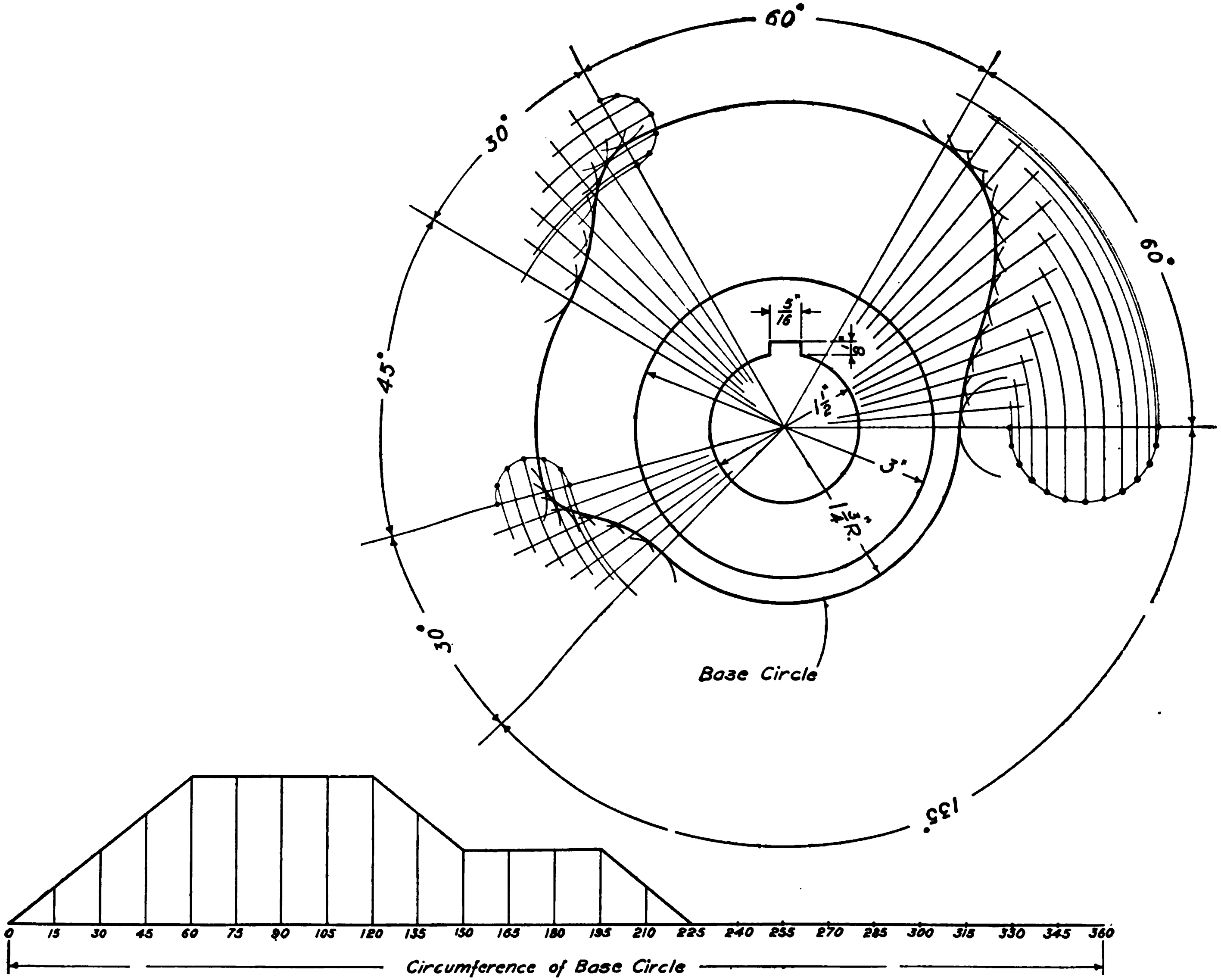



PLATE CAM

CLASS Industrial

NAME John W. Roberts DATE Jan. 12-09.

SCALE Full Size DWG. No. C-1052

# LESSON No. 57.

PERIPHERY CAM.—The Periphery or Cylindrical Cam illustrated in our present lesson is one of the many types of positive cams in general use. This cam operates a lever with a "throw" or radial movement of $1\frac{1}{2}$ inches. The small circles shown in the development of the groove represent the roller in different positions during the movement.

The formulas given are based upon an angle of 30° which is tangent to the middle point of the center line of the cam groove, as shown in the illustration. The value of $n$ in the formulas equals the number of degrees of the circumference occupied by the movement.

It has been found that 30° is the *maximum* angle we can use to obtain the best results, and from the above-mentioned formulas we can get the *minimum* cam diameter, using this angle.

The purpose of the chart is to show a graphical picture of the cam movement; thus it will serve as a general layout for the movements of all the cams on a machine.

For most movements straight lines from point to point will answer on a chart, and as they are more easily and quickly drawn than the true lines, much time may be saved by their use, but the student should realize that the actual path of the roller is a curved line, as illustrated by the cam-groove development, and for special cases it is necessary to plot these movements carefully.

Lay out a full-size pencil drawing (on a B-size sheet) of a periphery cam with a throw of $1\frac{1}{2}$ inches, forward movement of the lever roller to take place in one-sixth of a revolution or 60°, to pause at the end of the stroke 35°, and to return to rest in 60°, the lever to remain at rest for the balance of the revolution. The lever arm is 10 inches long to the fulcrum.

The distance B can be calculated from the chart, the length of which equals the cam circumference. Each vertical line represents 5°, and each horizontal line equals $\frac{1}{4}$ inch.

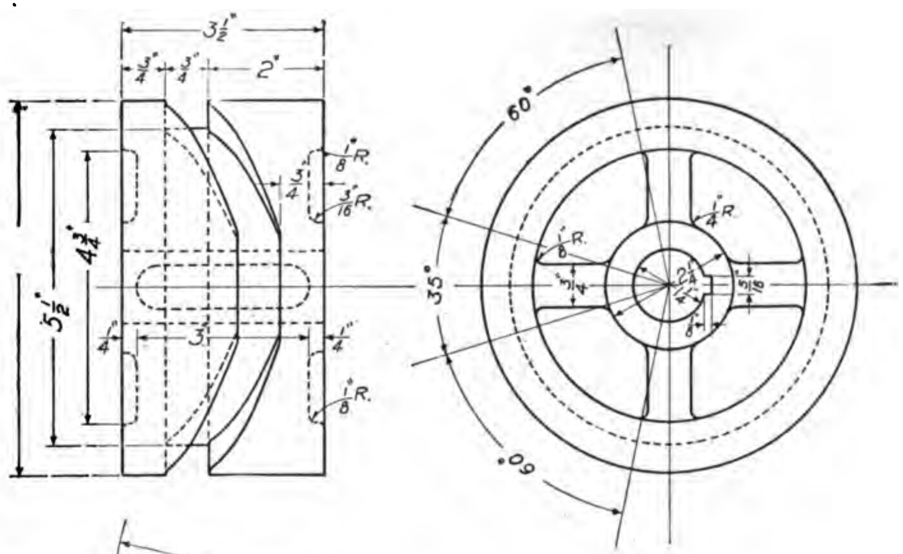
Do this work very carefully and accurately, making a tracing of the finished pencil drawing.

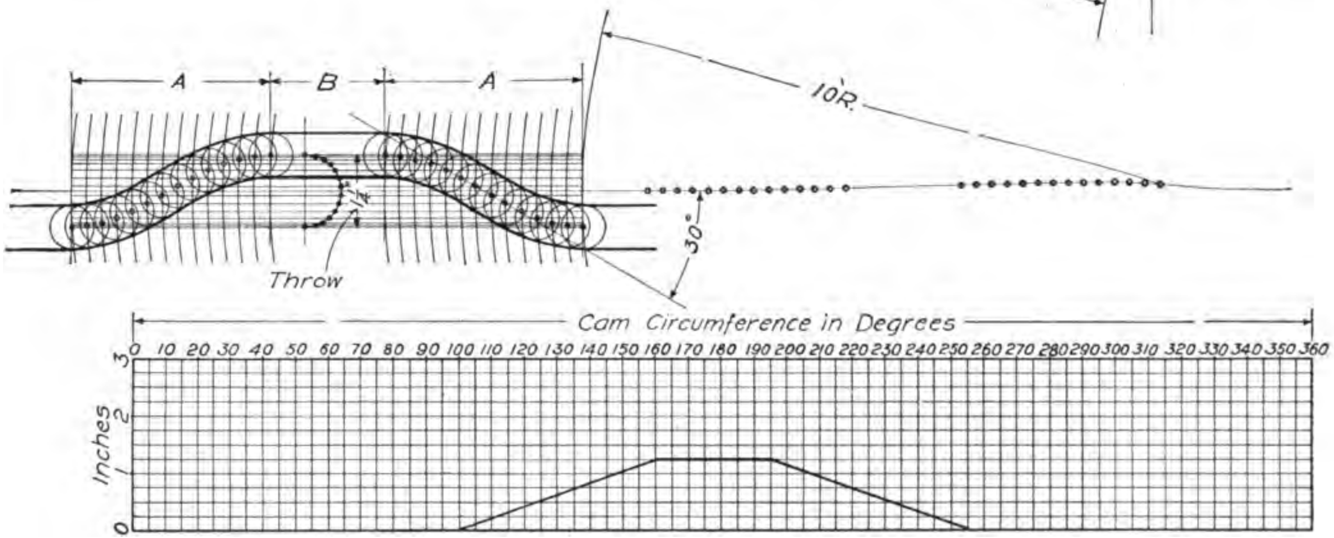
The formulas given are taken from "Design and Construction of Cams," by Smith and Halsey.

$$A = \text{Throw} \times 2.72$$

$$Cir. = \frac{2.72 \times \text{Throw} \times 360}{n}$$

$$Dia. = \frac{312 \times \text{Throw}}{n} \quad (\text{Approximation})$$




PERIPHERY CAM

CLASS *Industrial*

NAME John W. Roberts    DATE Feb. 10_09.

SCALE ½ Size    DWG. NO. C.1053

# LESSON No. 58.

STRUCTURAL DRAWING.—A general knowledge of the practice in structural drafting rooms is of value to the mechanical draftsman, even though he stick to machine work for a livelihood, as there are frequently times when it is necessary to do some special work pertaining to building construction.

The following lessons were planned for the purpose of familiarizing the student with general practice as to the conventional signs and methods in use in most structural drafting rooms.

Make a neat pencil drawing and tracing of the subjects shown on Drawing C–1054.

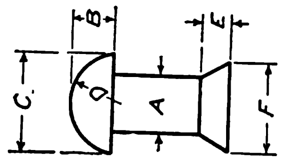
These signs for riveting are in general use by manufacturers of structural steel. The rivet proportions given are for the use of the draftsman only, and are intended for his convenience when indicating rivets on drawings of structural shapes.

"Shop Rivets" is the term used in designating rivets that are to be driven in the shop.

"Field Rivets" is the name given to rivets left to be driven during the erection of the structure.

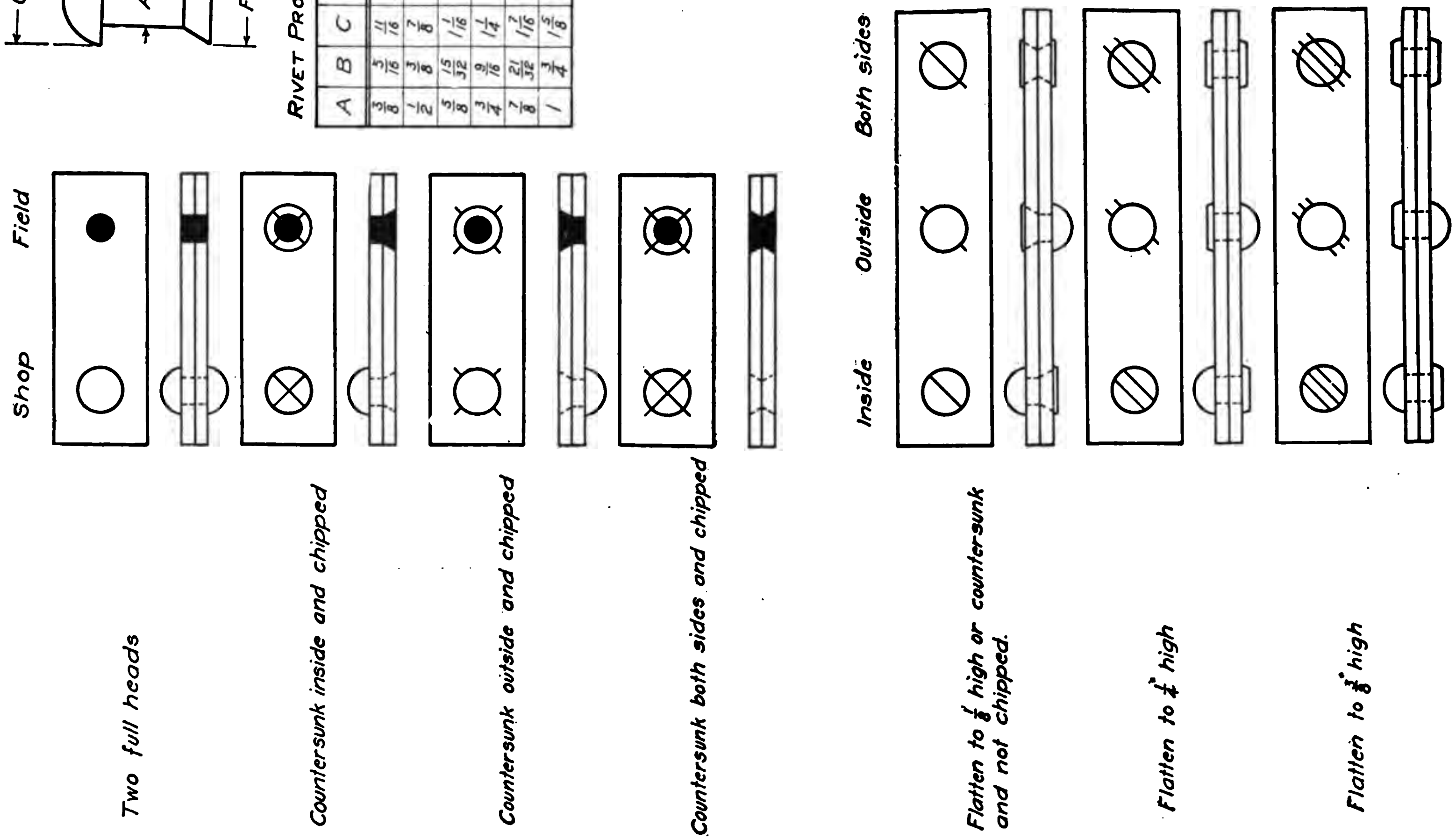
In reference to the terms "inside" and "outside": by the term "inside" is meant the side of the work that is behind or invisible, and the term "outside" refers to the side that can be seen on the drawing.

In making this drawing the student is at liberty to use any size rivets or plate thickness he may desire, though ½-inch rivets and ¼-inch plates were used in the illustration.




**RIVET PROPORTIONS**

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| $\frac{3}{8}$ | $\frac{5}{16}$ | $\frac{11}{16}$ | $\frac{11}{32}$ | $\frac{3}{16}$ | $\frac{9}{16}$ |
| $\frac{1}{2}$ | $\frac{3}{8}$ | $\frac{7}{8}$ | $\frac{7}{16}$ | $\frac{1}{4}$ | $\frac{3}{4}$ |
| $\frac{5}{8}$ | $\frac{15}{32}$ | $1\frac{1}{16}$ | $\frac{17}{32}$ | $\frac{5}{16}$ | $1$ |
| $\frac{3}{4}$ | $\frac{9}{16}$ | $1\frac{1}{4}$ | $\frac{5}{8}$ | $\frac{3}{8}$ | $1\frac{3}{16}$ |
| $\frac{7}{8}$ | $\frac{21}{32}$ | $1\frac{7}{16}$ | $\frac{23}{32}$ | $\frac{7}{16}$ | $1\frac{3}{8}$ |
| $1$ | $\frac{3}{4}$ | $1\frac{5}{8}$ | $\frac{13}{16}$ | $\frac{1}{2}$ | $1\frac{9}{16}$ |




CLASS *Industrial*

NAME *John W. Roberts* DATE *Feb. 16-09.*

RIVET PROPORTIONS
CONVENTIONAL SIGNS

SCALE DWG. NO. C-1054

# LESSON No. 59.

RIVETED JOINTS.—The riveted joints most used in structural work are "lap joints" where the plates overlap, and "butt joints" where the ends of the plates butt together, with other plates placed over the seam on each side.

The terms "single riveted," "double riveted," and "chain riveted" are clearly indicated on Drawing C–1055, and should need no explanation.

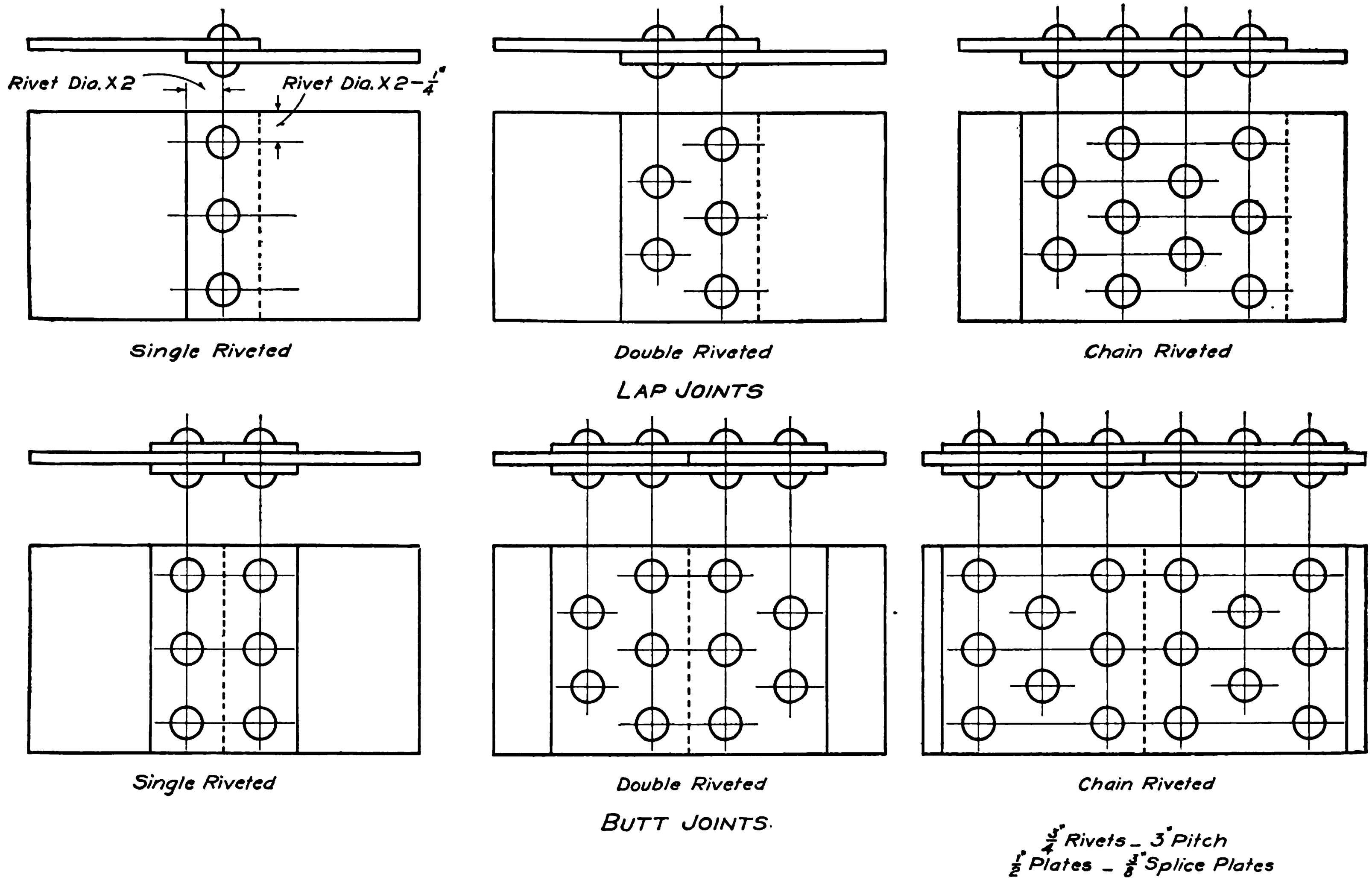
The distance from center to center of rivets is called the "pitch." In the present lesson the pitch is 3 inches.

While rules often vary with different firms, it is generally considered good practice, when locating rivets in relation to the sides and ends of the plates, to use the rules shown on the illustration.

Three-fourth-inch rivets are used in this lesson; the sizes of the heads can be obtained from Lesson No. 58.

The student should notice that the method of indicating the scale of the drawing differs from that used on drawings of machinery. He can readily understand why drawings of machinery are proportioned to the inch, while those of buildings, bridges, etc., should be per foot.

Make a neat pencil drawing and tracing of this lesson.




## RIVETED JOINTS

CLASS Industrial

NAME John W. Roberts DATE Feb. 18 - 09.

SCALE 3" = 1'-0" DWG. NO. C-1055

# LESSON No. 60.

STANDARD FRAMING.—Make a neat pencil drawing and tracing of the examples of Standard Framing shown on Drawing C–1056.

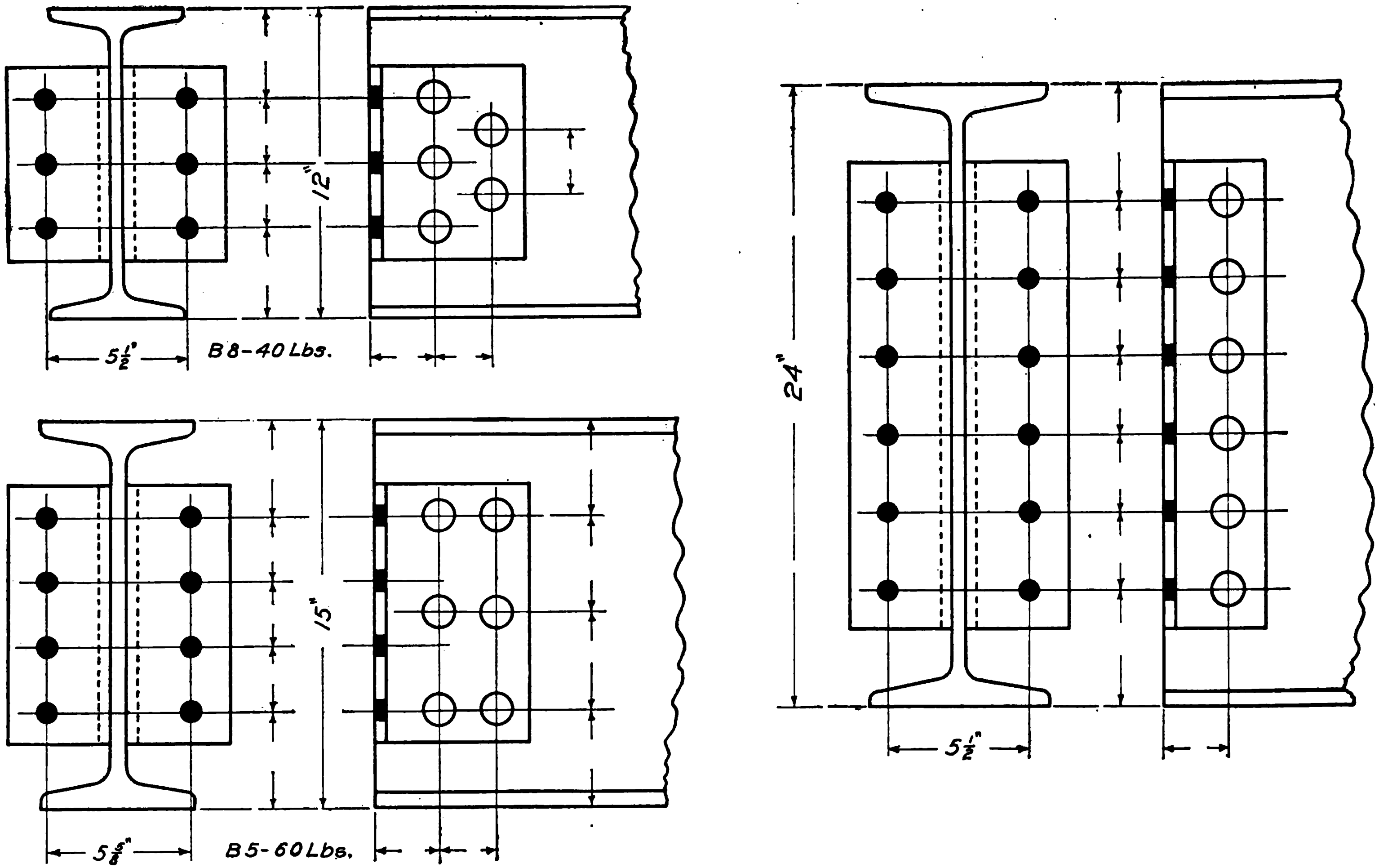
Most of the dimensions have been left off of the illustration, as it is not customary to show dimensions of I beams, but to give the depth and length with dimensions for rivet holes.

All necessary information to make this drawing, such as size of angles, positions of rivets, and dimensions of I beams, may be obtained from the handbook of the Carnegie Steel Company.

"L's" is the term commonly used to indicate "angles," as sections of angle iron are called. Thus "2 L's $4'' \times 4'' \times \frac{7}{16}'' \times 1'\ 6''$, wt. 43 lbs.," describes briefly a pair of angles the legs of which are 4 inches, the thickness $\frac{7}{16}$ inch, the length 1 foot 6 inches, and the weight 43 lbs.

Three-fourth-inch rivets are used; the size of head and the conventional sign for field rivets can be obtained from Lesson No. 58.

Make this drawing to the scale given, and put in the dimensions relating to the rivets, as shown by the dimension lines.




STANDARD FRAMING

CLASS Industrial

NAME John W. Roberts DATE Feb. 24_09

SCALE 3" = 1'-0" DWG. No. C.1056

# LESSON No. 61.

BEAM CONNECTIONS. — Two connections which are quite generally used to fasten large I beams to columns are shown on Drawing C–1057.

The connections for smaller beams are usually much simpler than those shown, so that the student should have no trouble to understand them should it be necessary for him to do some structural work.

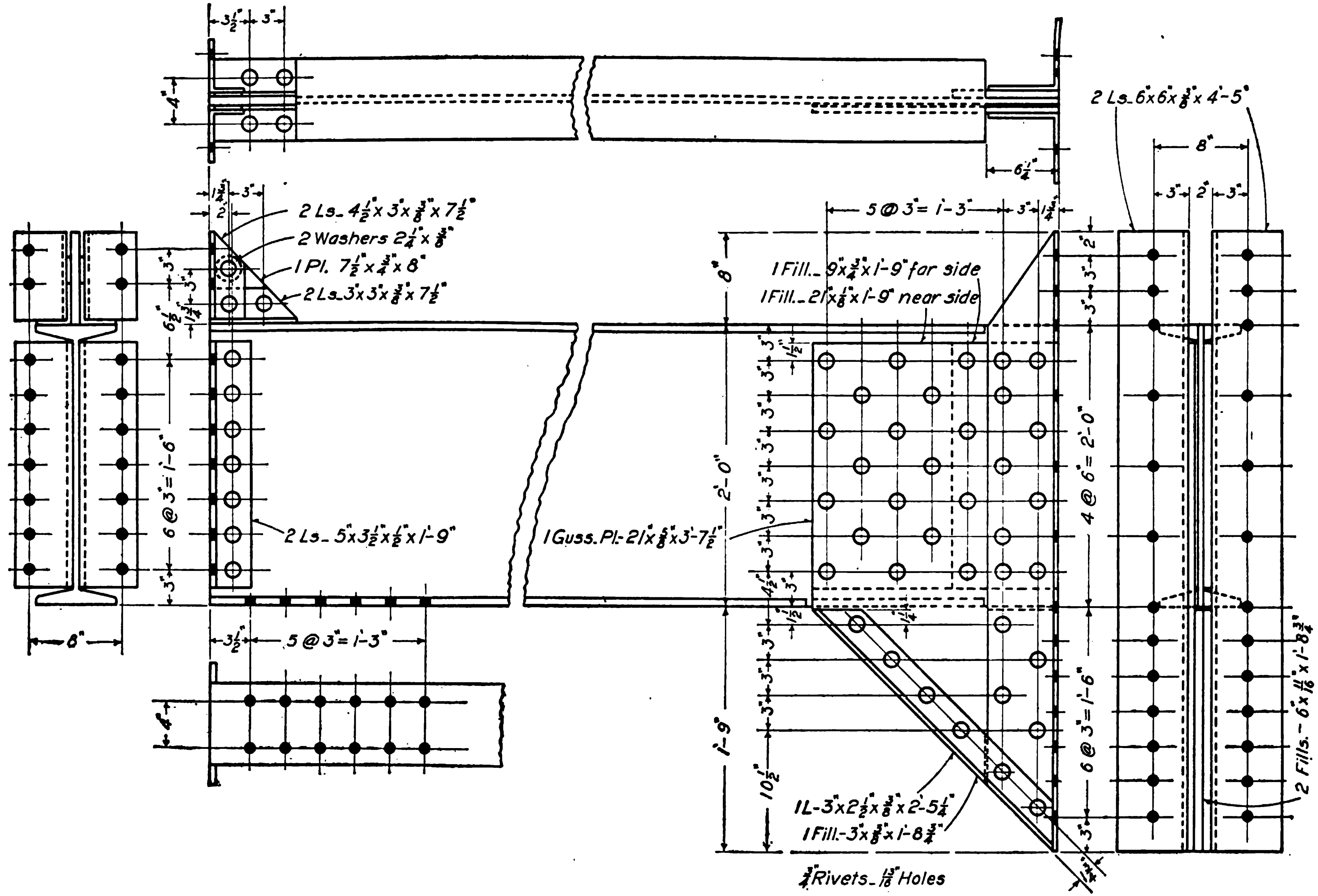
The student should observe the method used to designate the various details, such as "L's" for angles, "Pl." for plate, "Guss." for gusset plate, and "Fill." for filler plate.

A great deal of time and labor are saved by the method illustrated of indicating the dimensions of a detail, and the drawings are less complicated than they would be if each detail were dimensioned, as is necessary on drawings of machinery.

A careful study of these details will help the student to a clearer understanding of the methods followed in building up beam connections.

Notice also the method shown for dimensioning rivet spacing; this saves repeating a small dimension several times.

Make a pencil drawing and tracing of this lesson.




# BEAM CONNECTIONS

CLASS Industrial

NAME John W. Roberts DATE Feb. 26_09.

SCALE 1½" = 1'-0" DWG. No. C_1057